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Tobacco — Hazards to Health and Human Reproduction

Summary. The use of tobacco is one of the foremost public health problems in the world today. In the developed countries, tobacco-related disease subtracts 5 to 10 years from the life of the average male smoker. Tobacco also adversely affects the outcome of some pregnancies. In developed countries public recognition of the danger is beginning to discourage smoking, especially among the better-educated. In the developing countries, however, there has been little attention to the hazards of smoking, and tobacco consumption has been increasing by about 5 percent annually. Governments have found it difficult to adopt vigorous, health-oriented tobacco policies partly because of the substantial export and tax revenues derived from tobacco. Nevertheless, health professionals should be aware of the full range of risks associated with tobacco. Especially those who work in maternal and child health and family planning should understand the dangers that tobacco poses for the reproductive process and for infants and children so that they can educate prospective parents to these dangers.

The impact of tobacco on health has been amply documented. As the 1979 report of the US Surgeon General on smoking and health confirms, the death rates of US men who smoke cigarettes are about 10 times higher for lung cancer, 5 times higher for bronchitis, emphysema, and asthma, and 2 to 3 times higher for heart disease than of men who do not smoke. The risk of death is somewhat lower for pipe and cigar smokers, for those who do not inhale, for those who use filter cigarettes, and for women, but for all smokers the risk of death increases progressively with the amount smoked. In the developing countries, the long-term costs of tobacco use are just beginning to be apparent, although the link between tobacco use and morbidity and mortality has long been recognized — for example, the relationship of chewing tobacco and oral cancer in India.

In the developed countries, twenty years of publicity about the dangers of smoking are beginning to have some effects in reducing smoking. Between 1964, when the first US Surgeon General's report on smoking and health was released, and 1975 the percentage of males smoking declined from 52 to 39 and the percentage of females dropped from 34 to 29. Among US male college graduates the percentage of smokers fell from 42.5 to 28.1 between 1964 and 1975. In Britain surveys of 60,000 male physicians showed that between 1951 and 1965 half gave up smoking. As a result death rates of physicians for tobacco-related diseases dropped sharply below the death rates of the male population as a whole.

In the developing world, opposite trends seem to be at work. Smoking is a symbol of modernism, Western ways, and affluence — as tobacco advertising constantly emphasizes — appealing to the educated elites in the cities and to those with some cash income. Smoking is on the increase among university students, including those at medical schools. At the University of Lagos, for example, in 1976 nearly three-quarters of male medical students and one-quarter of female students described themselves as tobacco users. The expanding markets of the developing countries, where there are few restrictions on sales, promotion, and advertising, look increasingly attractive to tobacco companies which face ever more regulation and restriction in the developed countries. While the worldwide manufacture of Western-style cigarettes is growing, in rural or poor populations home-grown tobacco, potent leaf-wrapped or hand-rolled cigarettes, pipe tobacco, chewing tobacco, and other mixtures remain popular among women as well as men.

Use of Tobacco during Pregnancy

Although much of the early research on tobacco dealt with adult males, the fact that young women are smoking in larger numbers is focussing more attention on the impact of smoking upon the process of human reproduction and specifically upon the development of the fetus and the infant. In general, that impact is adverse. Smoking during pregnancy is associated with:

- lower birth weights
- shortened gestation
- higher rates of spontaneous abortion, especially during the last months of pregnancy
- more frequent complications of pregnancy and labor
- and, most important, higher rates of perinatal mortality.

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For a healthy, well-nourished woman in her 20s who smokes in moderation and has access to good medical care, the additional risk of a stillbirth or infant death attributable to smoking is small, probably no more than 10 to 20 percent greater than for a nonsmoker. By contrast, for a heavy smoker who is older, poor, or anemic, the risk of losing her baby may be as much as 100 percent higher. In Bangladesh, for example, among women with no formal education and low hemoglobin levels, perinatal mortality was twice as high among smokers as among nonsmokers. Although the exact manner in which tobacco affects birth weight, perinatal mortality, and other aspects of pregnancy is not clear, researchers suspect that carbon monoxide or nicotine or both are responsible.

Even after birth, the infants of mothers who smoke may face additional problems. Some studies have found evidence of increased congenital abnormalities among these infants, including cardiovascular changes that might lead to later coronary disease. If mothers who breast-feed smoke, their infants will imbibe nicotine and possibly more DDT, with unknown consequences. Infants in families where one or both parents smoke are more likely to develop bronchitis and pneumonia during the first year of life. The danger of Sudden Infant Death Syndrome (SIDS) is also suspected to be greater in families where the mother smokes.

Some effects may persist into childhood. For example, the children of British mothers who smoked were found to be about one centimeter shorter than the children of nonsmokers. More important, they scored slightly lower in reading, mathematics, and "general ability" tests than the children of nonsmokers. But it is hard to prove that smoking alone caused such differences.

As the public recognizes some if not all of these dangers, governments in the developed countries have been placed under growing pressure over the last two decades to take action, and now they are gradually beginning to do so. Policy changes in this area do not come easily, however. In the US, for example, efforts to promote anti-smoking policy by the American Cancer Society, the Surgeon General, many health professionals, and now many of those who have stopped smoking are opposed by tobacco growers, tobacco manufacturers, advertisers, media dependent on tobacco advertising, retail distributors, and some individual smokers. Tax revenues of about \$6 billion contribute to government reluctance to act.

As of 1974, 20 of 25 developed countries surveyed had taken some regulatory action against smoking as compared with only 13 of 49 developing countries. Since then many have increased taxes and a few have imposed stricter regulations. Finland, Norway, and Sweden among the developed countries and Singapore among the developing countries have probably gone furthest to institute anti-smoking policies. This means moving "from an implicit tobacco policy serving predominantly commercial and fiscal interests towards an explicit health-oriented smoking control policy" (137). Of international agencies, the World Health Organization (WHO) has taken the initiative in pointing out the health hazards of smoking and in recommending vigorous governmental anti-smoking policies.

Among the actions governments could take to implement "a health-oriented smoking control policy" would be:

- expanding research
- undertaking public education campaigns
- raising taxes, especially on high tar and nicotine products
- establishing government standards for production
- reducing export subsidies
- eliminating agricultural extension and government support services
- requiring health warnings and contents labelling on tobacco products and advertising
- limiting or prohibiting advertising
- limiting sales, e.g., to minors or in certain areas
- prohibiting smoking in public areas and in work places
- setting differential life insurance rates for smokers

No government has yet adopted the whole gamut of actions that would constitute a "health-oriented" tobacco policy, but there is ample opportunity for health professionals to move in that direction. Working from maternal and child health centers and in clinic or community-based family planning programs around the world, health professionals and community leaders are in constant touch with fertile couples and families. They could help all these families to reduce infant mortality, to improve the conditions of reproduction, and to protect the development of the next generation by discouraging the spread of a pernicious habit.

End of summary.

"There is a real danger of this deadly habit being exported to the younger countries of Africa and Asia, and the Western World has a responsibility to see that this is not done. . . . We have already produced millions of slaves to cigarettes in our own land. To export this slavery to the developing countries would be very wrong."

Editorial
British Medical Journal
October 9, 1971

TOBACCO, HEALTH, AND MORTALITY

Strong scientific evidence of the health hazards of smoking tobacco began to appear in the 1920s and 1930s when health personnel and statisticians noted both an increase in male rates of death from lung cancer and a large proportion of smokers among men who developed lung cancer (13, 240). In 1938, one of the first American demographers, Raymond Pearl, then at the Johns Hopkins School of Hygiene and Public Health, published a study of tobacco use and longevity based on life tables of 6,813 white males (196) (see box, p. L-5). Among men between the ages of 30 and 50, age-specific death rates for all causes were approximately twice as high for heavy smokers as for nonsmokers, and at each age fewer smokers than nonsmokers survived (see Figure 1).

Lung Cancer

Although greeted at first with skepticism, these findings were reinforced in the 1950s and 1960s by an increasing number of US, British, Canadian, and Japanese case-comparison (or retrospective) and cohort (or prospective) studies that identified not only a direct association between smoking and lung cancer but also a dose-response effect: death rates increased proportionately with the average number of cigarettes smoked daily (27, 36, 56, 57, 99, 100, 112, 122, 268). Animal studies substantiated these results. The epidemiologic studies showed mortality rate ratios for males ranging from approximately 2:1 to 10:1 for light cigarette smokers compared with nonsmokers and up to more than 20:1 for heavy smokers. The mortality ratios are lower for pipe and cigar smokers (27, 56, 57, 99, 100, 122), for women (99), for those who do not inhale, for those smoking filtered cigarettes, and for ex-smokers, whose risks diminish as time since they quit elapses (257).

One of the strongest pieces of evidence linking smoking and death comes from a study of nearly 60,000 British physicians (56, 57). Not only did those who smoked die earlier, but also those who gave up the habit had nearly normal life spans. Between 1951 and 1956, about half of the 43 percent of the doctors who had been cigarette smokers gave up the habit. Between 1953-57 and 1961-65 lung cancer death rates for the male population as a whole (of whom nearly half were smokers) increased by 7 percent whereas the death rates for the male physicians fell by 38 percent (56, 57, 214).

In the United States, as Table 1 shows, lung cancer death rates increased about fivefold between 1945 and 1975, creating what the Public Health Service has described as "an alarming epidemic" (257). These mortality trends, together with cohort and case-comparison data and animal studies, "confirm the conclusion that cigarette smoking is the main cause of lung cancer in men" (257). In the next decade lung cancer will exceed breast cancer as the major cause of deaths from cancer in US women (259).

Tobacco use increases the risk of other cancers as well, especially in tissues that come into contact with tobacco particles and smoke. Risks of dying from cancer of the larynx, for example, are 6 to 10 times higher for cigarette smokers than for nonsmokers (257); risks of dying from cancer of the esophagus, 2 to 6 times higher. Case-comparison studies have estimated the risk of death from bladder cancer to smokers to be twice as high as to nonsmokers, and large-scale cohort studies show that this heightened risk is dose-related (214). Other sites sub-

ject to higher risk of cancer from smoking or chewing tobacco include the pharynx, the oral cavity, the pancreas, the kidney (218, 257), and possibly the uterine cervix (270).

Lung cancer was the first disease to be clearly associated with smoking tobacco, and the 10:1 ratio of mortality rates for smokers compared with nonsmokers is higher than for any other major cause of death associated with tobacco use. Cohort studies have shown, however, that only about 15 percent of the total excess mortality among smokers can be attributed to lung cancer. The rest is caused by increased rates of coronary heart disease, chronic respiratory ailments, other cancers, and miscellaneous other causes of death (27, 56, 57, 99, 205).

Heart Disease

Diseases of the heart are a major cause of death in the industrialized countries. More Americans now die from heart disease than from any other ailment and almost ten times as many as from lung cancer (see Table 1). In the United Kingdom, heart disease accounts for about one-third of deaths among men between the ages of 35 and 64 (214). Numerous case-comparison and cohort studies have confirmed that cigarette smokers have significantly higher rates of death from coronary heart disease than nonsmokers, and that here too the risk increases with the number of cigarettes smoked (27, 56, 57, 100, 112, 122, 123, 213). In the absence of other predisposing factors, such as high serum cholesterol levels, high blood pres-

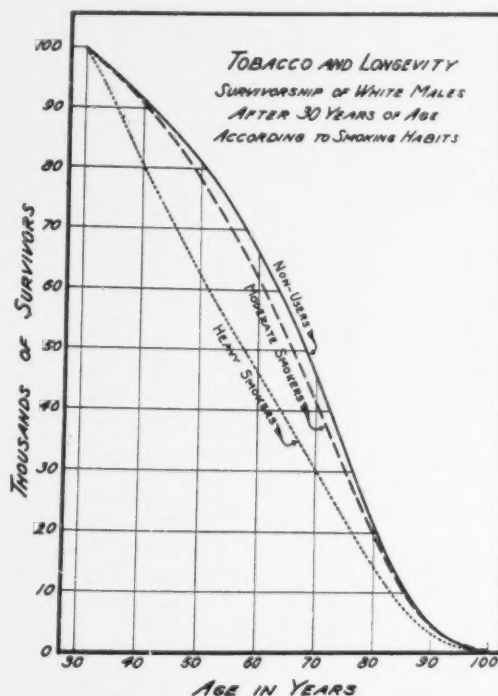


FIG. 1. The survivorship lines of life tables for white males falling into three categories relative to the usage of tobacco. A. Non-users (solid line); B. Moderate smokers (dash line); C. Heavy smokers (dot line).

Figure 1. Raymond Pearl's 1938 study of US men showed that fewer smokers than nonsmokers survived to every age between 30 and 70.

Source: Pearl (196)

Table 1. United States Mortality Rates for Selected Diseases, 1905-1975
(per 100,000 population)

Cause of death	Year							
	1905	1915	1925	1935	1945	1955	1965	1975
All causes	1,588.9	1,317.6	1,168.1	1,094.5	1,058.1	930.4	943.2	896.1
Tuberculosis, all forms	179.9	140.1	84.8	55.1	39.9	9.1	4.1	1.6
Malignant neoplasms of the respiratory system				4.9	10.4	18.2	27.7	40.7
Cancers of lung, pleura, bronchus & trachea								
Male						28.0	43.0	61.1
Female						5.0	7.7	17.0
Total		0.7	1.7	3.4	6.2	16.3	25.0	38.5
Diseases of the heart								
Male	167.4	168.6	195.9	277.0	400.1	425.8	435.3	385.2
Female	156.5	158.9	173.4	213.3	248.7	289.0	303.2	289.7
Total	161.9	163.9	184.8	245.4	320.3	356.5	368.0	336.2
Diseases of the respiratory system	202.0	159.9	107.5	93.2	54.4	38.2	51.6	52.6
Pneumonia	112.3	81.3	43.2	48.5	22.2	25.4	30.8	24.1
Bronchitis, emphysema & asthma*								
Male							24.3	31.6
Female							4.6	10.1
Total	35.7	20.1	8.3	4.7	4.5	7.7	14.9	20.6

Note: Because of international reclassifications of causes of death occurring each decade, mortality rates are not strictly comparable over long periods of time. Between the Fifth Revision, covering 1939-1948, and the Sixth Revision, covering 1949-1960, comparability of both lung cancer and bronchitis, emphysema, and asthma mortality is poor. Further, these rates are not age-adjusted, and so the increasing proportion of older age groups in the population leads to a higher incidence of certain diseases of old age (such as heart disease and lung cancer) than would occur if the age distribution were the same as in 1905.

*Bronchitis, emphysema, and asthma includes, for 1955 and 1965, ICD categories 500-502, 527.1, and 241; for 1975, ICD categories 490-493, 466, and 519.3 (chronic obstructive lung disease, not listed in 1965).

Source: US National Center for Health Statistics (202, 250, 251)

sure, obesity, or diabetes, males who smoke more than 20 cigarettes a day have a mortality rate 2 to 3 times that of nonsmokers (123). There is a definite but much smaller risk of heart disease for pipe and cigar smokers, for women, and for ex-smokers. As in the case of lung cancer, the contrast between British doctors and the male population of England and Wales in general is instructive: in the periods under study, cardiovascular disease death rates for male doctors fell by 6 percent whereas rates for the male population as a whole rose 9 percent (159).

Tobacco use also contributes to cerebrovascular disease and to a wide range of other circulatory system disorders, including arteriosclerosis, the stiffening and hardening of the arteries, and particularly arterosclerosis, the accumulation of fatty materials (lipids) along the walls of medium and large arteries. Both conditions diminish the blood supply available to the heart and other organs (257).

Nonmalignant Respiratory Disease

A third major area of smoking-induced morbidity and mortality is nonmalignant respiratory disease. Smokers are more likely than nonsmokers to suffer and to die from bronchitis, asthma, emphysema, and other disorders of the respiratory system. Moreover, a substantial number of deaths attributed to other causes may be hastened by pulmonary function that is abnormal due to smoking (257). The mortality rate ratios for chronic bronchitis are between 3:1 and 10:1 for smokers compared with nonsmokers, and the rate ratio for deaths from emphysema among heavy smokers is over 20:1 (257). In the study of British physicians, deaths from bronchitis were over 20

times more frequent among those smoking 25 or more cigarettes daily than among nonsmokers. Among the physicians as a group, mortality from bronchitis dropped 22 percent between the 1950s and the 1960s, compared with a reduction of only 4 percent among the total male population (56, 57, 214).

The total impact of tobacco on mortality in a developed country like the United States can only be estimated, but it is clearly large. In an analysis of 1966 data, R.T. Ravenholt calculated that approximately 301,560 deaths in the US from cancer, circulatory system disease, and respiratory ailments were caused by tobacco, compared with 307,310 caused by all infections, accidents, suicides, homicides, and diabetes combined (206). Using the ratio of lung cancer deaths to all excess tobacco-induced deaths of 1:6, he recently estimated that as many as one-quarter of US deaths annually may be attributed to tobacco use (205). From another perspective, E.C. Hammond has calculated that a 25-year-old US male smoking 20 cigarettes a day cuts his life short by over eight years (98), an

"Today there can be no doubt that smoking is truly slow-motion suicide. . . . It is nothing short of a national tragedy that so much death and disease are wrought by a powerful habit often taken up by unsuspecting children. . . ."

Joseph A. Califano, Jr.
Secretary
US Department of Health,
Education, and Welfare

estimate since confirmed (210). In England, the Royal College of Physicians figured that the average British male smoker at the age of 35 reduces his life span by 5½ years (214).

The health toll of smoking should be measured not only in mortality but also in morbidity. Smokers have more coughs, colds, minor respiratory infections, shortness of breath, and allergy problems than nonsmokers; they take longer to recover from many respiratory conditions and also, often, from surgery. Moreover, smokers are twice as likely to develop peptic ulcers. In addition to causing personal nuisance and discomfort, tobacco-induced morbidity is estimated to cost as many as 50 million work days every year in Britain (214) and 81 million in the United States (259).

Mortality and Morbidity in Developing Countries

While the epidemiologic information on tobacco-related morbidity and mortality in the developing countries is not nearly as extensive as in the industrialized nations, it is nonetheless clear that tobacco users everywhere suffer from illnesses caused by their habit. The most extensive research on tobacco-related disease in the Third World has taken place in India and began at the turn of the century. Since then a number of studies have described cancers of the oral cavity, which have constituted 15 to 70 percent of all cancers reported in some areas of the country (116). Indian research has associated oral cancers with chewing tobacco, chewing mixtures of tobacco, betel nut, and other ingredients, and smoking homemade cigars in reverse, with the burning end inside the mouth (218). A large survey in the 1960s found oral cancers in almost 52 per 100,000 people (116).

One recent product of Indian research, indicative of its sophistication, is a case-comparison study of 683 male lung cancer cases and 1,279 controls. The study found that cigarette smokers, compared with nonsmokers, faced a relative risk of lung cancer of 2.36. Men who smoked *bidi*, a cigarette of local tobacco rolled in a *temburni* tree leaf, faced a relative risk of 3.38. These relative risks are considerably less than those observed in studies in developed countries. Relative risk differed between Moslems and Hindus, even after stratification for frequency and duration of smoking, which, on the average, did not differ between the two religious groups (190). The researchers ask whether genetic or dietary factors might explain both the low incidence and the difference between religions (190). Inhaling practices, which might help explain both points, were not studied.

Other research on tobacco use and cancer in India has produced these findings:

- For women, the relative risk of developing carcinoma of the hard palate associated with smoking *chuttas*, a type of homemade cigar, with the lighted end inside the mouth was 132 times that for other women (300).
- Cancer of the cheek was eight times more common among those who chewed a mixture of tobacco, lime, and betel nut chips than among those who did not. The effect was related to the amount chewed and the frequency and duration of chewing. Incidence was 30 times higher than for nonusers if the user kept the quid in his mouth all night (304).
- Contradicting the common assumption that traditional forms of tobacco use are less dangerous than smoking manufactured cigarettes, in a series of 25 cases of bronchial cancer in men of the Kashmir Valley, only 2 were

cigarette smokers, while 17 smoked only *hookahs*, or water pipes, and 3 smoked both (297).

Reports of cancer associated with tobacco use have recently begun to come from other developing countries as well. A case-comparison study in Rhodesia found 87.5 percent of 32 African lung cancer patients smoked compared with 22 percent of 32 controls. The authors point out that the absence of air pollution in Rhodesia means that cigarette smoking is probably the most important cause of lung cancer there (89). In a South African study of lung cancer, all of the 45 cases but 60 of 90 controls were or had been smokers, and a greater proportion of the cases smoked large amounts of tobacco daily (219). In 500 men with cancer of the larynx in Morocco, only 52 (7 percent) were nonsmokers. Some 80 percent smoked at least 20 cigarettes a day, and 90 percent had smoked for at least 10 years (32).

A large study in Pakistan of 1,192 cases of carcinoma of the oral cavity and oropharynx and 3,562 controls found that chewing betel nut and tobacco increased risk by four times in males and three times in females. Smoking increased risk fivefold in males and 12-fold in females. The highest risks — 10 times higher for

From Raymond Pearl's "Tobacco Smoking and Longevity," 1938

"In the customary way of life man has long been habituated to the routine usage of various substances and materials that are not physiologically necessary to his continued existence. Tea, coffee, alcohol, tobacco, opium and the betel nut are statistically among the more conspicuous examples of such materials. . . . All of them contain substances of considerable pharmacologic potency if exhibited in appropriate dosage. . . . The situation so created is an extremely complex one behavioristically, and not a simple physiological matter, as it is sometimes a little naively thought to be. Purely hedonistic elements in behavior, which are present in lower animals as well as in man, have a real importance. Indeed they frequently override, in their motivational aspects, reason as well as purely reflex physiological inhibiting factors. There are undoubtedly great numbers of beings who would continue the habitual use of a particular material they liked, even though it were absolutely and beyond any question or argument proved to be somewhat deleterious to them. Most of them would rationalize this behavior by the balancing type of argument — that the keen pleasure outweighed the relatively (in their view) smaller harm.

The purpose of this paper is to report a part of the results of an investigation of the influence of tobacco upon human longevity. . . . (T)he net conclusion is clear. In this sizable material the smoking of tobacco was statistically associated with an impairment of life duration, and the amount or degree of this impairment increased as the habitual amount of smoking increased. . . . (T)he differences between the usage groups in specific mortality rates . . . practically disappear from about age 70 on. . . . (T)hose individuals in the damaged groups who survive to 70 or thereabouts are such tough and resistant specimens that thereafter tobacco does them no further measurable harm as a group."

Source: Pearl (196)

men and 13 times higher for women — were associated with chewing tobacco. Smoking a *hookah* carried with it more than three times the risk of smoking cigarettes, and smoking *bidis* was more than seven times as risky as smoking manufactured cigarettes (293).

In 131 Singapore Chinese with esophageal cancer, the relative risk of smoking hand-rolled cigarettes of Chinese tobacco was 2.5 for men and 6.25 for women, both statistically significant ($p < 0.01$). Smoking Western cigarettes was associated with relative risks greater than 1.0 but less than 1.5 — not statistically significant. After several factors were considered jointly, drinking hot beverages proved to be more strongly associated with esophageal cancer than smoking Chinese cigarettes (291). In a Rhodesian study, all 26 male esophageal cancer patients smoked compared with 14 of 26 controls of the same age and sex. Alcohol consumption was also associated with cancer, although not as strongly (306). In a series of 260 consecutive cases of lung cancer seen in Hong Kong, 92 percent of the 180 men and 56 percent of the 80 women smoked. By comparison, a survey of 1,347 men and 1,428 women in the general population found that only 59 percent of the men and 11 percent of the women smoked. Use of a kerosene stove was also associated with lung cancer in women (295).

Chronic obstructive lung disease associated with smoking has been reported from places as diverse as Papua New Guinea, Guyana, and Jamaica. In countries like these, G.J. Milner points out, other factors associated with the disease — atmospheric pollution, a cold damp climate, and industrial hazards — are absent, making the association with smoking clearer. Miller considers smoking to be the major cause of chronic cough and phlegm in the West Indies (170). In Papua New Guinea, in a population where smoking cigars of local tobacco was almost universal, those who inhaled had more chronic lung disease than those who did not (11). In a survey of 2,360 Indian men, chronic bronchitis was diagnosed in 15 percent of smokers and 5 percent of nonsmokers (296). Another Indian survey reported chronic bronchitis in 12.5 percent of 473 men aged 17 to 64. While under 4 percent of the nonsmokers had bronchitis, over 20 percent of the smokers did, even though none of the men smoked more than 20 cigarettes a day (294). Peptic ulcer associated with smoking has been reported from the developing world just as it has from the developed. A household and office survey in Chandigarh, India, detected 22 cases of peptic ulcer in men. Of these, 11 were smokers. Of 2,013 men without ulcers, 28.1 percent smoked. The difference is statistically significant ($p < 0.05$) (303).

Reports from developing nations of vascular diseases linked to smoking are now beginning to appear in medical literature. G.J. Miller, studying 32 survivors of heart attack and 93 controls in Jamaica, found that 15.6 percent of the heart attack cases smoked more than 20 cigarettes a day at the time of the attack compared with 4.3 percent of the controls, for a relative risk of more than four (287). M.A. Dolder and M.F. Oliver, examining risk factors in 240 male survivors of heart attack from seven centers in developed countries and two in developing areas — Bombay and Singapore — found no statistically significant differences in the prevalence of smoking among the groups from various cities, suggesting that smoking plays a role in heart attack etiology everywhere. Smoking, in fact, was the most common of the nine risk factors studied, prevalent in 69 percent (in the US) to 86 percent (in Singapore) of the men (55). Indonesians with peripheral arterial disease had a poorer prognosis if they smoked *kawung*, cigarettes of strong home-grown tobacco rolled in sugar palm leaf, than if they smoked *kretek* cigarettes, a commercial mixture of better grade tobacco with

cloves and spices in a paper wrapper, or Western cigarettes, even though they did not smoke more heavily (292).

These studies are examples from the growing body of research on the health effects of tobacco in the developing world. The fact that relationships between tobacco and disease have been less frequently reported than in the industrialized countries seems due to the lack of research, not the absence of disease in tobacco users. The prevalence and incidence of such diseases in developing countries and the degree of risk smoking poses deserve further research.

Harmful Components of Tobacco Smoke

Over four thousand compounds have been identified in the mixture of gases and tarry droplets that make up tobacco smoke (259). Over 30 of these, including the radioactive element polonium 210, are known or suspected contributors to the health hazards of smoking (257), but three in particular have been singled out as the agents most active in causing or promoting disease: carbon monoxide, nicotine, and tar (214, 257, 277). All three are toxic to humans, present in sufficient quantity to be hazardous, and readily absorbed by the exposed tissues, organs, and body fluids.

Carbon monoxide is a colorless, odorless gas produced by incomplete combustion. It makes up about 3 to 5 percent of cigarette smoke (262), depending in part on the porosity of the wrapper paper (277). The smoker who inhales is exposed to a concentration of about 400 parts per million (214). Nonsmokers in a room full of tobacco smoke (sometimes called "passive" or "involuntary" smokers) may inhale concentrations of carbon monoxide as high as 25 to 100 parts per million (143).

The hemoglobin in human blood, which carries oxygen throughout the body, has an attraction to carbon monoxide that is more than 200 times stronger than its attraction to oxygen (142). The strength of this bond, formed with the iron atom of hemoglobin, explains the poisonous nature of carbon monoxide (142). The resultant compound, carboxyhemoglobin, is unable to carry oxygen; as much as 10 percent of the blood's capacity to carry oxygen may thus be lost (91). Carbon monoxide also increases the affinity of hemoglobin for oxygen. This means that release of oxygen to other tissues is impeded (262). Due to these combined effects, blood carboxyhemoglobin concentrations as low as 4 to 5 percent can alter mental ability and performance in normal adults (142). Carbon monoxide may also increase the formation of fatty deposits on arterial walls (214).

Nicotine is a dense, oily alkaloid that has no therapeutic uses (51). The nicotine content of tobacco varies by type of tobacco and the form in which it is used. Pipe tobacco contains between 0.6 and 1.43 percent nicotine by weight; cigars, 0.75 to 3 percent; and cigarettes, 0.9 to 1.96 percent (262). Smokers who inhale absorb as much as 90 percent of the nicotine in their cigarettes (214), an amount ranging from 0.04 to 3.5 mg per cigarette (214, 262). About 60 mg of nicotine is an acutely fatal dosage, but as little as 4 mg can produce symptoms of toxicity in a person whose body is not accustomed to the drug (51). Because the smoke of cigarettes is acidic, nicotine is absorbed mainly after it has entered the lungs; pipe and cigar smoke, on the other hand, is alkaline, which means that more nicotine is absorbed through the lining of the mouth and pharynx (214).

The effects of nicotine on the various tissues of the body are wide-ranging and complex. Nicotine can act on the central nervous system either as a stimulant or a sedative, depending

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An estimated 4.9 million metric tons of tobacco were produced worldwide in 1977. (University of Kentucky College of Agriculture)

on the dose and the tobacco user's physiological and psychological constitution (214). Nicotine injections and cigarette smoking both produce the release of adrenaline and noradrenaline and directly influence the nerve centers controlling blood pressure and heart rate. The result in normal individuals is an increase in heart rate, blood pressure, cardiac output, heart stroke volume, velocity of heart contraction, myocardial oxygen consumption, and cardiac arrhythmia (214). Nicotine, both injected and in cigarette smoke, may also raise the content of fatty acids in the blood and stimulate blood platelets to cling to one another and to the walls of blood vessels (214).

Nicotine, the most powerful pharmacological agent in tobacco, is also thought to be responsible for the "smoking habit," that dependence on smoking which makes it difficult for smokers to give it up. As the Royal College of Physicians points out, "the remarkable spread of smoking throughout the world and the difficulty that most smokers find in abstaining suggests that the craving has a pharmacological basis" (214).

Carbon monoxide and nicotine exert a combined action on the heart: carbon monoxide reduces the amount of oxygen avail-

able to the heart while nicotine spurs cardiac activity, which increases the heart's need for oxygen. Together with the increased growth of fatty deposits on arterial walls that is attributable to both substances, the increased burden on and stimulus to cardiac function help explain the role of tobacco in coronary heart disease (262), especially acute coronary insufficiency and myocardial infarction.

"Tar" is a dark brown, viscous material composed of condensed particles from cigarette smoke that remain after moisture and nicotine are removed. It is here that known and suspected cancer-initiating and cancer-promoting agents reside. Chief among the known cancer initiators, or carcinogens, in tar are the polycyclic aromatic hydrocarbons (214). More virulent carcinogens such as nitrosamines and beta-naphthylamine are present in smaller amounts (277). The cancer promoters include phenols and fatty acids and their esters (214). They have been known to produce cancers both on the skin of laboratory animals and when inhaled by animals.

Acting separately and in combination, these three ingredients — carbon monoxide, nicotine, and tar — have been repeatedly implicated as responsible for the health hazards of cigarette smoking. While products with lower tar and/or nicotine seem less dangerous, in any amount they have adverse effects on animals and humans.

Research Problems

Although higher death rates from lung cancer have long been statistically associated with cigarette smoking, association per se does not prove a causal link. Proof of a genuine cause-and-effect relationship, as the Surgeon General's Advisory Committee Report emphasized in 1964 (258), depends on the consistency, strength, specificity, temporal relationship, and coherence in the associations noted (258). Another consideration is biological plausibility (110).

With respect to lung cancer, certain respiratory diseases, and a number of cardio- and cerebrovascular conditions, causal relationships with smoking have now been substantially documented. The consistency (or replicability) of findings has been shown, particularly among males, in many different countries, times, and studies. The strength of the relationships is evident not only in high risk ratios in case-comparison studies and high incidence rate ratios in cohort studies, but also in sharply rising national death rates accompanying expanding use of tobacco. The specificity of the association is clear with respect to lung cancer and emphysema, if less so for the broader category of coronary heart disease. The temporal relationship of smoking and various pathologies is documented by correlations between the rate of smoking and the increases in national death rates, and it is reinforced by the falling death rates now beginning to appear for men who have stopped smoking. The coherence of the evidence is apparent not only from the dose-response curves, which show that incidence rates increase linearly with the number of cigarettes smoked per day, but also from the common elements of animal studies, autopsy, and laboratory evidence, which elucidate the biological processes involved in pathogenesis. Altogether the evidence presents a comprehensive scientific indictment of cigarette smoking as a major factor in recent increases in male mortality in many developed countries.

Nevertheless, there remain characteristics of tobacco products, tobacco use, and tobacco users that pose special problems in studying the health consequences of smoking. For example, tobacco has a variety of forms — chewing tobacco, cigars, pipes, and cigarettes — and each form offers innumerable

**Tobacco is a filthy weed,
That from the devil does proceed;
It drains your purse, it burns your clothes,
And makes a chimney of your nose.**

Oliver Wendell Holmes (1809-1894)

choices of strength, texture, and, in the case of cigarettes, filter, paper, and other ingredients. Each of these variations may affect the risk of tobacco use. Even more important may be individual habits: whether or not the smoker inhales and, if so, how deeply; how many times each cigarette is put into the mouth and how long it is left there; and how far down each cigarette is smoked—an especially important variable since tar and nicotine accumulate near the end of a cigarette as it is smoked and thus are inhaled in greater amounts as the cigarette is smoked to its end. These variables can obscure relationships between the amount smoked and the extent of exposure and make it difficult to categorize smokers by dosage. The effect may be to dilute the apparent strength of dose-response relationships. More attention is needed to developing standard measurements of smoking experience (207).

An even more serious set of research problems resides in the nature of tobacco users themselves. Smoking is statistically associated with certain demographic, psychological, and social characteristics, including age, race, and social class (as indicated by occupation, education level, income, or, in the case of hospital studies, private versus public payment status).

In the US and Britain personality traits seem to be related to smoking, and many studies have been undertaken to try to identify differences between smokers and nonsmokers (106, 117, 118, 138, 153, 221, 234). Commenting on this research, the Royal College of Physicians observed:

Smokers tend to be impulsive, arousal-seeking, danger-loving risk-takers who are belligerent towards authority. They drink more tea, coffee, and alcohol, and are more prone to car accidents, divorce, and changing of jobs. Some of these characteristics collectively imply a degree of extraversion. Cigarette smokers have been found, on average, to be more extraverted than nonsmokers (70, 71, 72, 227). Although the differences are highly significant statistically, they are small and there is a great overlap between smokers and nonsmokers, so that personality characteristics do not reliably predict which individuals will become cigarette smokers (214).

In other words, to the extent that people who smoke may be less careful about their health in other ways as well, this tendency could contribute to higher death rates quite independently of their smoking habit. Those who question a cause-and-effect relationship between tobacco and various diseases suggest that these personality and behavioral differences contribute substantially to higher mortality (72, 106). None of these studies, however, has quantified the effects of personality on the incidence of specific illnesses such as lung cancer, nor can personality traits be identified that might constitute a "smoker's personality" (153). In fact, the US Surgeon General's report estimates that variations in personality can account for only 3 to 5 percent of the variance in measurement of smoking habit (259). In a carefully designed study, then, these personality variations could only account for a small amount, if any, of the excess mortality that has been observed among smokers. However, studies should control for any variations in behavior that could affect health independent of smoking.

In looking specifically at the impact of tobacco on reproductive health, one major problem is the relatively small amount

of research on women smokers. The research gap, now gradually being filled, is due to the fact that women began smoking later than men in most developed countries and that the percentage of women smokers, although increasing, is still well below that of men in almost all countries (see p. L-27). In addition, fertility and the outcome of pregnancy are influenced by many different variables, including not only the fecundity and health of the mother, but also the health of the father, the condition of the fetus, and myriad environmental factors. All those variables need to be taken into account in studies of tobacco and reproductive health.

Finally, much of the early research on outcome of pregnancy and on maternal and child health was not carried out with the same epidemiologic sophistication and attention to multiple variables as more recent studies of steroidal contraception or IUDs, for instance, where research findings can make the difference between introducing and discarding a new product. Nor are the studies on pregnancy as clear cut or as conclusive as the lung cancer and tobacco studies.

There is also little research from the developing countries, where tobacco is rapidly gaining popularity. Although tobacco use seems related to the same diseases seen in developed countries (179), other conditions and predisposing factors may be very different from those in developed countries so the incidence of diseases in smokers may differ. For example, the lower incidence of circulatory system diseases in many developing areas may mean that smoking would produce less increase in cardiovascular and cerebrovascular mortality. On the other hand, conditions that combine with tobacco use to markedly increase the complications of pregnancy may be more common in some developing areas. Also, nutritional deficiencies are more widespread and more severe in many developing countries, and may, in association with smoking, cause or promote adverse conditions. Clearly the proven hazards of tobacco use for males in the developed countries should stimulate more attention to the potential hazards for men, women, and children throughout the world.

PREGNANCY AND CHILDBIRTH

Smoking during pregnancy retards fetal growth and increases the risks of spontaneous abortion, complications of pregnancy, preterm delivery, and late fetal and newborn death. These findings emerge from several decades of research on maternal smoking and the outcome of pregnancy, including a number of studies with populations large enough for researchers to identify those who face especially high risks from smoking (see Table 2).

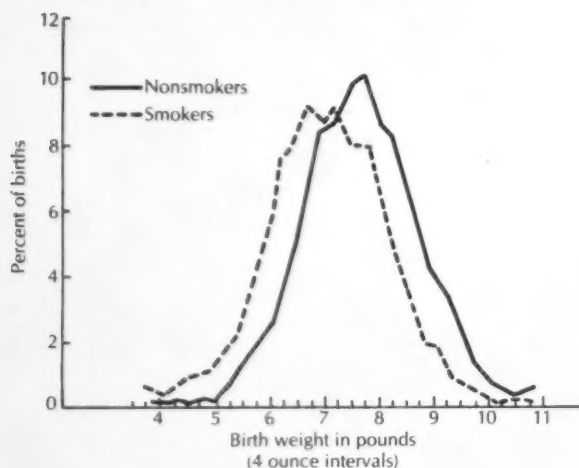
Birth Weight

The clearest finding of research to date is that smoking mothers are more likely than nonsmokers to give birth to underweight babies. According to the 1979 United States Surgeon General's report *Smoking and Health*, more than 45 studies, involving a total of over half a million births, have confirmed that maternal smoking decreases birth weight. The observation is consistent across national, racial, socioeconomic, and geographic lines (259). The fact that the babies of tobacco users have reduced chances for survival is not a result of their low birth weights;

Table 2. Description of Major Studies of Smoking During Pregnancy, 1958-1968

Study Name	Ref. No.	Population	Data Gathering Method	Number Initially Enrolled	Length of Study	Smoking Information Recorded
British Perinatal Mortality Survey	39, 40	Notified/registered births in England, Scotland, and Wales, March 3-9, 1958, and all neonatal deaths in March, April, and May 1958	Questionnaires filled out postpartum by midwives and doctors; follow-up studies of surviving children at 7 and 11 years of age, conducted by the National Child Development Study	17,204 births (approximately 98 percent of all births); 7,851 stillbirths and neonatal deaths	Births: March 3-9, 1958 Neonatal deaths: March, April, May 1958	Number of cigarettes smoked daily in period before pregnancy and at end of fourth month of pregnancy
Cardiff Births Survey	12	All births to women residing in the city of Cardiff, Wales	Interviewed postpartum by Births Survey clerk or midwife	18,631	1965 to 1968	Number of cigarettes smoked daily during pregnancy; "ex-smokers" defined as those who stopped smoking before pregnancy
Child Health and Development Studies	261, 272, 282, 283	Births to women enrolled in pre-paid medical program in the San Francisco-Oakland Bay Area, USA	Interviews early in pregnancy and medical record data beginning before pregnancy; follow-up studies of children at 5 and 10 years of age	Approximately 15,000 pregnancies; nearly 100 percent participation	1959 to 1967	Age at which smoking began; number of cigarettes smoked
Collaborative Perinatal Study of the National Institute of Neurological Disease and Stroke	189	Sampling of approximately 132,000 pregnancies to women at urban university-affiliated US medical centers, including re-registration for later pregnancies	Data collection at prenatal clinic visits and before and after delivery; follow-up studies of surviving children at 8 months, 1, 4, 7, and 8 years of age	53,180; 3.3 percent drop-out rate	1959 to 1965	Number of years of smoking and usual number of cigarettes smoked per day at time of registration
Ontario Perinatal Mortality Study	167, 168, 169	All births at 10 Ontario, Canada, teaching hospitals	Interviews with mothers after delivery; interviews with anesthetists and attending physicians	51,490 (smoking status known for 50,267)	January 1960 to December 1961	Maximum amount smoked at any time during pregnancy, in packs per day
United States Navy Obstetrical Study	37, 242	Deliveries to women at 44 United States naval bases worldwide	Information obtained by attending physicians at admission of women to labor room	48,505	July 1, 1963, to June 30, 1965	Number of cigarettes usually smoked per day and cigarettes smoked during each trimester of pregnancy
(No name) Conducted by the Institut National de la Santé et de la Recherche Medicale	95, 223	Women consulting at 13 Paris hospitals before the third month of pregnancy, with subsequent exclusion of those not born in France, not giving birth at one of the 13 hospitals, and smokers of less than one cigarette per day	Interviews in hospitals	14,548 (reduced to 6,989 by 1969 due to exclusions)	Began 1963	Smoking before pregnancy and during pregnancy to point of consultation; cigarettes per day (heavy smoker = 10 cigarettes per day) and whether or not smoker inhales
(No name)	133	Pregnancies to women in Malmö, Sweden	Self-administered questionnaires provided by gynecologists at time of diagnosis of pregnancy and at subsequent visits, resulting in coverage of the entire pregnancy	6,913; follow-up of 92.2 percent	1963-1964	Number of cigarettes currently smoked per day and in each gestational month, asked on each questionnaire

Figure 2.
Distribution of Birth Weight by Maternal Smoking Status*



*Smokers were those who consumed 20 or more cigarettes per day during pregnancy.

Source: MacMahon et al. (151)

nevertheless, the low birth weights of smokers' infants are an undeniable indication that smoking influences pregnancy, and they raise the possibility that the mechanisms responsible have other effects on the gestation process and the later health of offspring.

The reduction in birth weight from tobacco use may be expressed either as a decrease in the average weight of smokers' babies compared with those of nonsmoking women or as an increase in the percentage of infants who are under a certain weight, usually defined as 2,500 grams. The infants of smoking mothers have an average weight about 200 grams less than that of nonsmokers', and a greater percentage of smokers' babies weigh less than 2,500 grams at birth (12, 38, 43, 46, 73, 133, 146, 167, 172, 176, 189, 200, 208, 216, 217, 223, 242, 283, 285). The effect is dose-related. The more a woman smokes during pregnancy, the greater her chances of having an underweight baby (46, 73, 133, 189, 223, 261). Also, birth weight decreases steadily as the number of cigarettes smoked increases (40, 46, 242).

The effect of smoking is independent of other factors known to influence birth weight, such as the sex of the infant and the age, parity, race, social class, and size of the mother (12, 38, 40, 46, 73, 146, 167, 172, 217, 223, 261). Although infant weight at birth is determined by many genetic, environmental, and pregnancy-related factors, maternal smoking reduces birth weight regardless of the other factors at work: smoking during pregnancy shifts the whole distribution of birth weights, as shown in Figure 2. In fact, smoking is one of the most important factors determining birth weight. M.B. Meyer and colleagues' analysis of over 50,000 births in the Ontario Perinatal Mortality Study found that maternal smoking was associated with a larger difference in birth weight than any of the eight other relevant factors investigated, including history of pregnancy loss, pre-pregnant weight, and socioeconomic status (167).

Data from the developing world now confirm research in the industrialized nations. In order to gather better data from de-

veloping countries on key aspects of maternal health care and outcome of pregnancy, the International Fertility Research Program (IFRP) has developed an international Maternity Care Monitoring system. The data bank now includes information on 150,000 deliveries in developing as well as developed countries. The information recorded for each delivery includes birth weight, Apgar score (an index of the newborn's condition based on several factors), maternal education, maternal smoking habits, and some 50 other variables (26). A preliminary analysis by J. Fortney of developing country data from three continents shows, as expected, that birth weights under 2,500 grams occur more often among smokers' than among nonsmokers' babies. Even when the data are controlled for education, which is an important variable, the lowest birth weights are seen in the children of the heaviest smokers (see Table 3). Apgar scores, however, show no apparent link with the amount of maternal smoking. Other variables and possible associations have not yet been analyzed (79).

Smoking habits prior to pregnancy have no appreciable effect on birth weight (40, 207, 285), but there is a difference in findings as to the effect of smoking at various times during pregnancy. A few studies suggest that stopping smoking early in pregnancy eliminates tobacco's effect on birth weight (40, 58), but data from the US Navy Obstetrical Study showed lower birth weights among babies of mothers who smoked during any of the trimesters of pregnancy (242).

The lower average birth weights of smokers' babies cannot be explained as the result of shortened gestational age. First, the reduction in mean length of gestation due to smoking is not great. Expressed as a mean difference, the figures calculated by C.R. Buncher in the US Navy Obstetrical Study are typical; for the woman who smoked 20 cigarettes a day, a female birth would occur 29 hours earlier, a male birth 34 hours earlier than for a nonsmoker (37). It is doubtful that the mean weight differences between smokers' and nonsmokers' infants could be caused by such a short difference in gestational length. Second, among infants of the same gestational age, smokers' children have lower average birth weights than nonsmokers' (12, 38, 40, 167, 216, 223) (see Figure 3).

Causes of Low Birth Weight

Carbon monoxide. Although the causal mechanisms by which tobacco reduces birth weight have not been precisely identified, oxygen deprivation, caused by carbon monoxide, is the most likely explanation. Pregnant women, fetuses, and newborns may be especially vulnerable to oxygen deprivation. The body normally produces a certain amount of carbon monoxide from the breakdown of pigments in hemoglobin, but a pregnant woman's rate of endogenous production may be 50 percent higher than a nonpregnant woman's (140). At the same time, the oxygen-carrying capacity of the pregnant woman's blood is reduced some 20 to 30 percent because of a lower concentration of hemoglobin (142). This lower hemoglobin concentration may account for a rise in carboxyhemoglobin concentration after smoking a single cigarette that is significantly greater for pregnant women than for nonpregnant women (60). Carboxyhemoglobin concentration in the fetus is normally about 10 to 15 percent greater than in the mother, and its elimination by the fetus appears to lag behind maternal elimination (142). P.V. Cole and colleagues measured maternal carboxyhemoglobin levels at delivery in 222 women and found a mean level of 1.2 percent in nonsmokers and 4.1 percent in smokers. Levels in fetuses, they assumed, would be

Table 3. Percentages of Women in Developing Areas Delivering Infants with Birth Weights above and below 2,500 Grams, by Smoking Habit and Education, 1975-1978

Birth Weight (in grams)	Education (Years Completed)											
	None			1-6			7+			Total		
	None	Light	Heavy	None	Light	Heavy	None	Light	Heavy	None	Light	Heavy
Asia, developing¹												
<2500	35.9	49.0	71.4	25.9	30.2	66.7	17.8	30.6	25.0	23.3	42.3	57.1
≥2500	64.1	51.0	28.6	74.1	69.8	33.3	82.2	69.4	75.0	76.7	57.1	42.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	(2,445)	(143)	(7)	(4,476)	(43)	(3)	(7,768)	(36)	(4)	(14,689)	(222)	(14)
Latin America²												
<2500	9.6	8.7	11.9	7.9	9.3	9.8	7.7	9.7	8.8	8.0	9.4	9.8
≥2500	90.4	91.3	88.1	92.1	90.7	90.2	92.3	90.3	91.2	92.0	90.6	90.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	(4,522)	(633)	(446)	(30,512)	(4,344)	(3,706)	(19,304)	(3,568)	(1,000)	(54,338)	(8,545)	(5,152)
Mid East & Africa³												
<2500	5.5	6.3	6.7	6.0	10.7	25.0	6.4	10.7	25.0	5.8	7.9	13.0
≥2500	94.5	93.7	93.3	94.0	89.3	75.0	93.6	89.3	75.0	94.2	92.1	87.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	(11,292)	(95)	(15)	(4,655)	(28)	(4)	(2,682)	(28)	(4)	(78,629)	(151)	(23)

¹Asia, developing, includes Bangladesh, India, Pakistan, the Philippines, and Sri Lanka.

²Latin America includes Brazil, Chile, Colombia, El Salvador, Honduras, Mexico, Panama, Uruguay, and Venezuela.

³Mid East & Africa includes Egypt, Iran, Nigeria, Sudan, and United Arab Emirates.

Source: Fortney (International Fertility Research Program) (79)

correspondingly higher than those in the two groups of women (41).

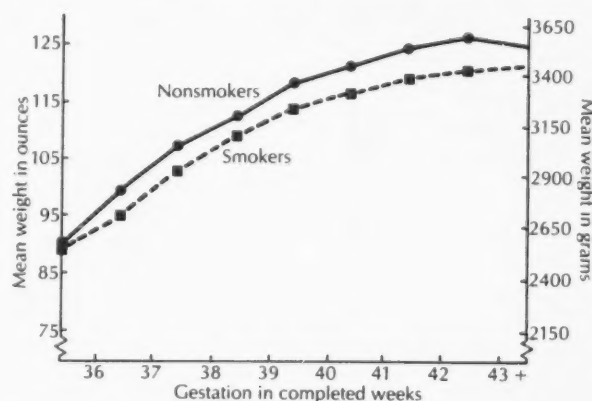
Elevated hemoglobin and red blood cell levels, signs of fetal adaptation to lack of oxygen, further implicate oxygen deficiency as the cause of low birth weight in smokers' infants. Higher levels in smokers' offspring have been found both in umbilical cord blood (61) and in the blood of 48-hour newborns (87). In the latter study the effect was dose-related. Levels in mothers were not affected by smoking (87).

The possibility that reduced oxygen supply during gestation leads to low birth weight is supported by similarities between the birth weights of smokers' infants and the birth weights of infants born to women living at high altitudes. Meyer notes that studies of births at high altitudes report a downward shift in the whole distribution of birth weights — a shift independent of gestational age. She also notes that weight decreases progressively as altitude increases, just as weight decreases progressively as tobacco use increases (168). In both cases, the small size of infants may be an adaptation that reduces the risk of death when oxygen is in short supply.

Examination of placentas provides more clues to understanding tobacco's effects on pregnancy. Although the babies of smokers are smaller than nonsmokers', their placentas are not; thus, the placental ratio (the ratio between placental weight and birth weight, also known as the placental coefficient) is higher for smokers (176, 271, 272). Meyer notes that studies find the same in births at high altitude (168). The higher placental ratio may indicate an adaptation to allow better oxygen transport to the fetus. R.L. Naeye, in a study of the placentas of 46,754 infants whose mothers reported their smoking habits in the Collaborative Perinatal Project of the US National Institute

of Neurological and Communicative Disorders and Stroke, found that in births at 33 or more weeks gestation the placentas of heavy smokers actually weighed more than those of light smokers and nonsmokers (183). Further, studies of high altitude births and of smokers' births both report structural changes in placentas that would increase their oxygen-diffusing capacity (168). A French study comparing the placentas of 248 women who smoked at least five cigarettes a day during pregnancy and

Figure 3.
Mean Birth Weight by Length of Gestation
and Maternal Smoking Status,
British Perinatal Mortality Survey



Source: Butler & Alberman (38)

those of 196 nonsmokers found a significantly higher number of abnormalities attributable to inadequate oxygen among the smokers' pregnancies. However, the researchers found no relationship between these abnormalities and birth weight (229).

Nicotine. In addition to carbon monoxide, nicotine may contribute to the smaller size of smokers' babies. A comparison of 209 infants born to mothers who chewed tobacco but did not smoke (and thus were not exposed to carbon monoxide from the combustion process) and 1,148 infants born to women who did not use tobacco in any form showed a clear deficit in birth weight of from 100 to 200 grams among the babies of tobacco chewers (131).

Although nicotine's effects on circulation are complex, the agent's powerful vaso-constricting action is likely to reduce placental blood flow, which may help account for the lower birth weights of smokers' infants. L.M. Hellman and colleagues found that cigarette smoking stimulated fetal tachycardia (unusually rapid heartbeat rate) as quickly as did an experience that frightened the mother. The speed of this reaction prompted them to suggest that a change in uterine circulation was responsible (107). A recent study in Finland helps substantiate their hypothesis: 12 subjects in good health who had completed at least 35 weeks of pregnancy experienced a decrease in placental intervillous blood flow immediately after smoking a cigarette. Within 15 minutes the flow had returned to normal (136).

The possible effects of carbon monoxide and nicotine upon birth weight might also be involved in the as-yet-unidentified mechanisms causing higher rates of pregnancy complications, preterm delivery, and perinatal loss among smokers. One hypothesis suggests that attempts to compensate for lack of oxygen either fail or lead to placental pathology, in turn producing complications and perinatal loss (162, 168). More research is needed on the relationship between undesirable outcomes of pregnancy linked to smoking and the effect of various tobacco components on placental and fetal development.

Cyanide. Vitamin depletion due to cyanide may also contribute to the lower weights of smokers' babies. Elevated levels of cyanide and thiocyanate (formed in the detoxification of cyanide) have been found in the blood and urine of pregnant smokers (200). Detoxifying cyanide requires increased vitamin B₁₂ and essential sulfur amino acids. Thus the detoxification process may deprive the fetus of these nutrients (149, 200).

Lower serum vitamin B₁₂ levels have been found among pregnant smokers than among pregnant nonsmokers, and measurements of B₁₂ levels made before the 20th week of pregnancy showed a consistent, although not statistically significant, positive relationship to birth weight (149).

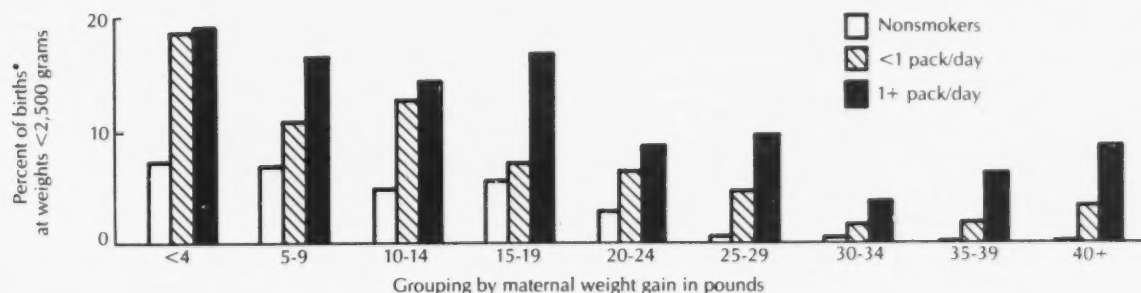
Other hypotheses. The bulk of the evidence suggests that carbon monoxide and nicotine are primarily responsible for lower birth weights. Other factors, such as maternal weight gain and constitutional (or self-selection) factors, are far less satisfactory explanations.

A few researchers have suggested that cigarette smoking depresses a woman's appetite during pregnancy and the decreased caloric intake accounts for lesser fetal growth — an opinion mirrored in the popular opinion that a pregnant woman can compensate for the effect of smoking by eating more. Researchers support this contention with evidence that the smoking mothers who had low birth weight infants had themselves gained less weight during pregnancy than had nonsmokers (53, 215). In addition, in the Collaborative Perinatal Project study of over 50,000 births, S. Garn and colleagues found that the infants of obese smokers were in fact heavier on the average than those of all nonsmokers. They did not, however, compare the obese smokers' infants with the infants of obese nonsmokers (83, 84).

Other research contradicts the nutrition hypothesis. In some studies, no appreciable differences in maternal weight gain between smokers and nonsmokers were found (62, 156, 164, 241). In the Ontario Perinatal Mortality Study, Meyer divided all smokers into maternal weight gain groups by five-pound intervals; within each group smokers delivered a higher percentage of infants weighing under 2,500 grams than did nonsmokers (see Figure 4) (164). She points out that at later stages of pregnancy an increasingly large proportion of weight gain is fetal growth as opposed to weight gain from added maternal tissue. Thus, smoking slows fetal weight gain, which in turn is reflected in less maternal weight gain. "The mother gains less weight in late pregnancy because the fetus gains less weight, and not vice versa" (164).

Data from the Collaborative Perinatal Project substantiate this observation, especially for women who smoked 20 or fewer cigarettes a day. Their lesser weight gain — averaging 90 grams less than for nonsmokers — was due entirely to the lighter weight of their infants. In the case of those smoking more, who

Figure 4.
Percentage of Underweight (<2,500 Gram) Births by Level of Maternal Smoking,
Grouped by Maternal Weight Gain, Ontario Perinatal Mortality Study



*Live births at 36 or more weeks of gestation to patients of public hospital status

Source: Meyer (164)

gained an average of 533 grams less than nonsmokers, about one-third of the deficit, or 150 to 200 grams, was due to the smaller size of the newborn (183).

The body proportions of underweight babies born to smokers do not resemble those of infants born to mothers with nutritional deficiencies. Infants of smoking mothers are more likely than nonsmokers' to have an abnormally short crown-heel length, in contrast to the "long, thin baby" of the woman who is undernourished (172). Thus the preponderance of evidence belies the widespread belief that eating more will compensate for the effects of smoking.

The self-selection argument also has been raised in the study of tobacco and birth weight, its proponents contending that low birth weight is due to the constitution of the *smoker* rather than to *smoking* per se (109, 282). Research findings on birth weight and tobacco militate against explanations involving inherent features of the smoker, however. Large-scale studies have consistently found a tobacco-related effect in subgroups known to have low weight infants and in a number of different cultures and countries. Consistent reports of a dose-response relationship also cast doubt on the self-selection argument, since a constitutional predisposition could explain such a phenomenon only if the degree of inherent tobacco craving and the degree of fetal growth retardation were related in a linear manner (86).

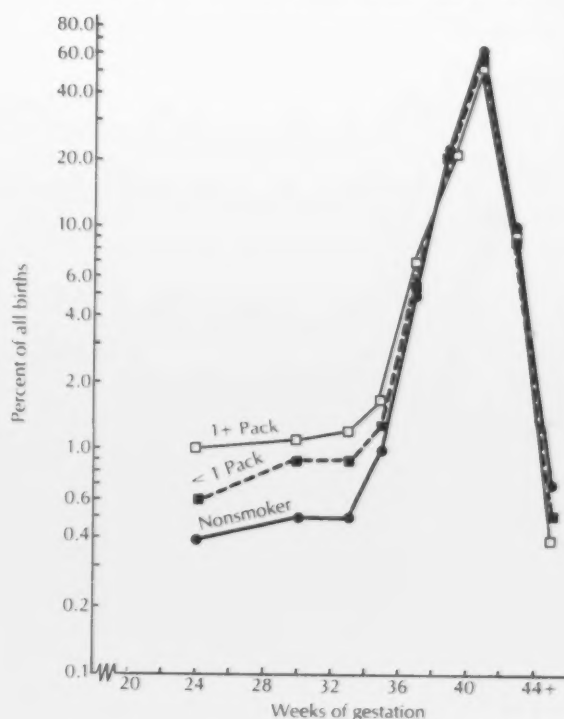
Another problem with the self-selection argument is that it does not propose a causal mechanism that can be tested: the postulated characteristics of smokers that differentiate them from nonsmokers are such all-embracing behavioral and personality variables that they cannot be specified or, consequently, tested (93). In contrast, researchers who cite specific causal agents in tobacco are able to link their research to a growing body of clinical and laboratory studies.

The best test of any self-selection hypothesis is to have cases serve as their own controls. Naeye's recent study of 2,100 repeat pregnancies in the same women revealed that those who smoked during one pregnancy but not another gave birth to smaller infants in the pregnancy during which they smoked. This difference occurred irrespective of eight other factors known to be associated with differences in fetal weight, among them birth order, sex of offspring, pre-pregnancy body weight, and socioeconomic status in the interval between pregnancies (183).

Length of Gestation

The developmental maturity of the fetus is a critical factor in its ability to survive, hence the importance of an optimal length of gestation. Smoking during pregnancy shortens the gestational period, but not uniformly for all pregnancies. Although this reduction in length of gestation has only a slight effect on overall averages, there is an observable increase, due to tobacco use, in the percentage of infants who are gestationally premature (12, 38, 73, 167, 283) (see Figure 5). For instance, data from a 1970-1971 Quebec study, in which the lengths of pregnancies and the smoking habits of more than 6,000 women were recorded, show that birth occurred before 38 weeks of pregnancy in 16.5 percent of the smokers compared with 12.2 percent of the nonsmokers (73). J. Andrews and J.M. McGarry reported that, of pregnancies resulting in live births, 9.2 percent of smokers had spontaneous deliveries before 37 full weeks of pregnancy as opposed to 6.7 percent of nonsmokers, with ex-smokers ranking between them, at 7.5 percent, in a statistically significant distribution (12).

Figure 5.
Distribution of Gestation Lengths by Maternal Smoking Level, Ontario Perinatal Mortality Study



Source: Meyer (162)

Meyer and colleagues found a dose-response relationship between the amount smoked and the number of gestations of less than 38 weeks. They ranked smoking third in strength among nine factors associated with shortened gestation length, exceeded only by history of pregnancy loss and by socioeconomic status as indicated by private versus public patient hospital status (167). No consistent dose-response relationship emerged in a US study of 4,183 births, but the effects of smoking on gestation length appeared to be more pronounced among blacks. Some 13.3 percent of babies born to nonsmoking black women were of less than 37 weeks gestation compared with 24.5 percent of babies born to black women who smoked 20 or more cigarettes daily. Among whites 4.4 percent of nonsmoking women had infants of less than 37 weeks gestation, while for women smoking 30 or more cigarettes daily the figure was 6.6 percent (146).

Maternal weight does not appear to alter the effects of smoking on gestation length. Examination of 271 spontaneous births before 37 weeks of pregnancy, reported in the British Perinatal Mortality Survey, revealed that smokers in all maternal weight groups had higher rates of spontaneous preterm births than nonsmokers. For example, among women weighing less than 50.8 kilograms at the start of their pregnancies, smokers had a prematurity rate of 33.7 per thousand in contrast with 25.0 among nonsmokers (75).

Complications of Pregnancy

Smoking is associated with complications of pregnancy and labor. The complications include premature rupture of membranes, bleeding during pregnancy, placenta previa (a placenta

that has developed so low in the uterus that it is in contact with or covers a part of the internal os of the cervix), and abruptio placentae (the premature detachment of the placenta).

Early rupture of membranes can bring on serious complications in the form of premature labor and intrauterine infection. The latter problem can result in fatal septic shock for the mother as well as illnesses in the fetus such as congenital pneumonia (24).

Bleeding in large amounts is an obvious risk to the pregnant woman. It is also associated with higher perinatal mortality: hemorrhage in the latter half of pregnancy, which takes place in about 3 percent of all births in the United States, accounts for one-fourth to one-third or more of perinatal loss (108). Smokers experience a 25 to 50 percent higher incidence of bleeding during pregnancy than nonsmokers (12, 146, 261). In the Cardiff study, this effect was independent of parity (12). The most common source of bleeding in the latter part of pregnancy is the placental area, and placenta previa or placental abruption is often the cause (94, 108).

These placental complications pose a serious threat to both perinatal survival and maternal health. Perinatal mortality rates in the Ontario Perinatal Mortality Survey stood at 26 per thousand for all births, but jumped to 109 per thousand in cases of placenta previa and 266 per thousand for abruptio placentae (167). Treatment of placenta previa may require cesarian section and transfusions for the pregnant woman. In the United States, use of these techniques since the late 1920s has markedly reduced maternal mortality from placenta previa (203). Placental abruptions typically result in maternal shock. In severe cases whole blood is needed immediately in large quantities in order to save the woman's life (108, 203). Both

placenta previa and abruptio placentae are more likely among women of high parity (108). In many developing areas where a large proportion of women giving birth are of high parity and optimal facilities for emergency obstetrical care are not readily available, these complications may be more frequent and pose a greater threat to maternal health and infant survival than in the industrialized countries.

The most detailed analysis of associations between smoking and complications of pregnancy comes from the Ontario Perinatal Mortality Study. Researchers found that smokers experienced an increased risk of placental complications that rose with the amount smoked. Expressed as a median increase, the risk to those who smoked fewer than 20 cigarettes daily amounted to 28 percent more than the risk to nonsmokers, and the risk to heavier smokers was 85 percent more than the risk to nonsmokers (167). The risk of placental complications for smokers became even more marked when deliveries took place early in gestation, as they are more likely to do in smokers. The same tendency was observed for premature rupture of membranes. Among deliveries before 34 weeks of gestation, the smokers' risk of premature rupture was three times greater than the nonsmokers' (168).

One fairly consistent finding in research on tobacco and complications of pregnancy is that the incidence of toxemia is lower among smokers than nonsmokers (12, 38, 133, 217). In the Cardiff Survey, 4.1 percent of smokers showed signs of mild to moderate pre-eclampsic toxemia (a toxemia of late pregnancy characterized by hypertension, albuminuria, and edema) as opposed to 5.8 percent of the nonsmokers (12). The agent in tobacco smoke that brings this about may be cyanide, by its metabolism to thiocyanate, which lowers blood pressure (12, 62). Despite this seemingly beneficial effect, if pre-eclampsia or hypertension does develop in the smoking woman, her infant runs a decidedly greater risk of perinatal death (12, 62, 217). Data from Scotland on cases of pre-eclampsia among 2,500 women having their first child revealed a perinatal mortality rate of 21.7 percent for smoking mothers, a striking contrast to the 8.5 percent mortality for births to nonsmoking pre-eclampsic women. Some 2.4 percent of the 939 smokers and 5.2 percent of the 1,604 nonsmokers were diagnosed as pre-eclampsic (62).

Spontaneous Abortion

Tobacco use during pregnancy may increase the incidence of spontaneous abortion (111, 114, 129, 133, 211, 223, 241). A recent case-comparison study of smoking and spontaneous abortion, conducted in New York and comprised of 574 women who experienced spontaneous abortions and 320 controls, estimated the risk of spontaneous abortion among women who smoked during pregnancy to be 80 percent higher than that among nonsmokers — a significant difference (129). Reanalysis of the data suggests that the risk is dose-related and is lower among women between 27 and 31 years of age than among those 18 to 26 and 32 to 40, although the difference was statistically significant only in the group under age 27 (150).

The New York research is especially noteworthy because it was conducted after abortion became legal in that state. Thus there was little danger that induced abortions would be reported as spontaneous, a problem that could not be excluded from other studies (133, 223). In a Swedish study Kullander and Källén found that, from the fourth through the seventh months of pregnancy, the proportion of miscarriages involving smokers



In 1975 only 60 percent of US women knew that smoking was harmful to the fetus. This poster from the American Cancer Society aims to broaden awareness of the risks of smoking during pregnancy. (American Cancer Society)

"Since it is so hurtful and dangerous to youth I wish that it might have the pernicious nature expressed in the name and that it were as well known by the name of youth's bane as by the name of tobacco."

"The copy of a letter written by E.D., Doctor of Physic, to a gentleman by whom it was published," London, 1606

increased (133). It has been suggested that the underlying causes of these late miscarriages could be the same as those that bring about perinatal mortality from placental complications. This is in contrast to fetal abnormalities, which typically account for a large percentage of earlier spontaneous abortions (1).

PERINATAL MORTALITY

The term perinatal mortality refers to both stillbirths and newborn deaths. It is usually defined as fetal deaths at 20 weeks or more of gestation plus neonatal deaths within the first week after delivery. Studies in both developed and developing countries show a higher risk of perinatal mortality to the offspring of women who use tobacco than to the offspring of nonusers. This mortality would include not only spontaneous abortions after the fifth month of pregnancy, noted above, and deaths resulting from specific complications of pregnancy and delivery, but also the many perinatal deaths for which precise causes of death are not known. Importantly, according to research findings from the developed countries, such factors as anemia, high parity, and low socioeconomic status, in themselves associated with high risk of perinatal death, yield even greater risks when combined with tobacco use.

Developed Countries

Unlike its effect on birth weight, the effect of maternal smoking on perinatal mortality is not felt equally in all childbearing populations; rather, it adds to the risk of those already more vulnerable for other reasons. The differences in the effect of smoking on different groups of women are probably the main reason that researchers have not obtained more similar results in their studies of smoking during pregnancy and its effects on perinatal mortality. As reviews of the literature on smoking and perinatal mortality point out (169, 201, 259), some studies do not standardize their data for other important factors and so may differ in their conclusions regarding the effect of smoking. Table 4 summarizes the results of selected major studies in developed countries on smoking during pregnancy and perinatal death without regard to other risk factors. Table 5, by contrast, reports a breakdown of risks associated with important subgroup characteristics and reveals the impact of smoking on specific subgroups.

Where researchers, setting aside the differences among subgroups, have estimated an average increased risk to smokers, their figures range from 24 to 43 percent (40, 43, 73, 216). Comparing smoking's impact with that of seven other factors linked to perinatal mortality, Meyer and colleagues ranked tobacco use fourth, after (1) history of pregnancy loss, (2) private versus public (government-supported) hospital patient status,

an indicator of social class, and (3) the combined factors of age and parity (167).

A clear dose-response relationship can be seen in the data on smoking and perinatal mortality (12, 46, 101, 169, 189, 223). When Meyer and colleagues investigated the effect of different amounts of smoking while controlling for seven other factors affecting perinatal mortality, the risk of perinatal death, compared with nonsmokers', was 20 percent higher for those smoking less than one pack (20 cigarettes) a day, but rose to 35 percent higher for those who smoked more (167).

Major factors that affect perinatal mortality include: prior pregnancy outcome, with a history of fetal death associated with increased risk (249); maternal age, with increased losses among women younger than 25 and older than 29 (249); parity, with first births and high parity births in more danger than second births (166, 249); social class, with increased mortality as socioeconomic status falls (38); and low maternal hemoglobin, which is found more often in higher age and parity groups and in lower social classes (38).

When these and other factors affecting risk of perinatal mortality are taken into account, the women who are in the greatest danger of losing their infants because of tobacco use can be identified. For example, among US white women in the upper socioeconomic strata who smoke lightly and are at optimal childbearing age and parity, the effects of tobacco are almost impossible to demonstrate (169); however, among US blacks, who have a lower standard of living, the rate of perinatal death for smokers' offspring may be as much as 86 percent higher than that for nonsmokers' offspring (216). Maternal smoking increases perinatal mortality risk 70 to 100 percent among infants of mothers in lower socioeconomic strata who are of high parity or have a history of delivering low birth weight infants (169).

The lesser probability of survival for smokers' babies is especially marked among women with anemia: the risk of perinatal death nearly doubles for offspring of anemic women who smoke 20 cigarettes or more daily (169). Severe anemia (defined as eight grams of hemoglobin or less per 100 ml of venous blood) may be as much as triple the risk of perinatal mortality due to smoking (169).

The pregnant woman who smokes may be aggravating anemia's effects on pregnancy in a number of ways. In T.F.B. Dow and colleagues' study of carboxyhemoglobin increase in response to cigarette smoking among pregnant and nonpregnant women, the greater rise in pregnant women was even more pronounced in cases of anemia (60). The depletion of vitamin B₁₂ stores due to smoking during pregnancy (150) might also aggravate an anemic condition and so its effect on fetal well-being. A US study of urban pregnant women discovered noticeably higher lead accumulation in smoking mothers and their fetuses. This higher lead level reduced the activity of an enzyme that assists red blood cells in making hemoglobin. However, the researchers did not find a correlation between lead levels and anemia (132).

The Search for Causes

The mechanisms or biological processes that bring about excess deaths among smokers' infants are not fully understood. Assigned causes of fetal and neonatal death suggest that perinatal loss associated with tobacco use is not a product of abnormalities of the fetus itself so much as a result of problems in the course of the pregnancy. The Cardiff community study

Table 4. Perinatal Mortality and Smoking during Pregnancy, Selected Studies of Single Births, 1967-1975

Author & Date	Ref. No.	Population	No. of Smokers	No. of Nonsmokers	Perinatal Mortality (per 1,000)		Rate Ratio ^a (Smokers/Nonsmokers)
					Smokers	Nonsmokers	
Andrews & McGarry 1972	12	Cardiff Births Survey: births to women residing in Cardiff, Wales, 1965-1968	7,570	10,176	29.1	24.4	1.19
Butler et al. 1972	40	Births in England, Scotland, and Wales, March 3-9, and all neonatal deaths in March, April, and May 1958	6,890	14,898	41.1	32.0	1.28 ^b
Comstock et al. 1971	43	Washington County, Maryland, USA, county records of live births and death certificates, 1953-1963	4,641	7,646	21.5 ^c	15.4 ^c	1.40
Cope et al. 1973	46	Government-supported and private status births, Sydney, Australia, hospital, September 1969 to December 1970	1,223	2,844	27.8	21.1	1.32
Fabia 1973	73	10% sample of birth certificates in Quebec, Canada, 1970-1971	3,004	3,954	16.9	13.6	1.24 ^d
Goujard et al. 1975	95	Deliveries in 13 Paris maternity hospitals, 1963-197	9,169		23.3 ^e	9.2 ^e	2.53 ^f
Kullander & Källén 1971	133	Prospective study of pregnancies in Malmö, Sweden, 1963-1964	2,458	3,282	25.2	17.7	1.42 ^g
Meyer et al. 1974	169	Ontario Perinatal Mortality Study, government-supported and private births, 10 Ontario, Canada, teaching hospitals, 1960-1961	21,909	28,358	29.5	23	1.28
Niswander & Gordon 1972	189	Prospective study of pregnant women admitted to clinics of 14 US hospitals, January 1959-December 1965	18,425	20,311	39.8	35.5	1.12
Rantakallio 1969	299	All liveborn and stillborn infants in Oulu and Lapland, Finland, weighing ≥ 600 gms	3,468	8,898	23.4	23.2	1.01
Rush & Kass 1972	216	Registrants at the Prenatal Clinic, Boston City Hospital, USA, 1961-1962	1,538	1,738	41.0	28.8	1.42
Underwood et al. 1967	242	Women giving birth at 44 US naval bases worldwide	24,865	23,629	20.8	19.7	1.06
Yerushalmy 1972	282	Child Health and Development Studies: prospective study of pregnancies to women in prepaid medical program in the San Francisco-Oakland Bay Area, 1960-1962	13,083		13.8	12.5	1.10

^a Authors make no statements regarding statistical significance except where noted.^b Statistically significant ($p < 0.001$)^c Neonatal deaths only^d Found not statistically significant^e Rates are for stillborns only^f Statistically significant ($p = 0.0001$)^g Separate risks before birth, during birth, and during the first postnatal week were not statistically significant.

found more pneumonia, respiratory distress syndrome, and immaturity, and fewer congenital malformations associated with neonatal deaths of smokers' infants than of nonsmokers' (12). In the Ontario Perinatal Mortality Study, the largest categories of causes of fetal death in smokers' pregnancies were "unknown" and "anoxia" (lack of oxygen); the fetuses were normal but had died nonetheless. Among causes of neonatal death, "prematurity alone" and "respiratory diffi-

culty" — signs that a normal baby was born too soon — were foremost (168).

Too short a pregnancy may be a key cause of perinatal death. Since gestational maturity is a critical determinant of perinatal viability, any factor that brings about an earlier delivery — as smoking does — will also increase risk of death. Looking at risk of perinatal death by length of gestation, Meyer and J.A. To-

Table 5. Perinatal Mortality and Smoking during Pregnancy, by Subgroup Characteristics, Selected Studies, 1969-1975

Author & Date	Ref. No.	Subgroup ¹	Perinatal Mortality (per 1,000)		Rate Ratio (Smokers/Nonsmokers)
			Smokers	Nonsmokers	
Butler & Alberman 1969	38	Class²			
		social classes I & II	26.3	25.8	1.02
		social classes III	49.0	34.1	1.44
		social classes IV & V	41.1	31.7	1.30
Cope et al. 1973	46	Dosage³			
		light smokers	25.4	21.1	1.20
		heavy smokers	29.9	21.1	1.42
Fabia 1973	73	Parity			
		0	18.7	14.2	1.32
		1-3	11.2	11.2	1.00
		4+	36.1	21.8	1.66
Meyer et al. 1974; Meyer 1979	165, 169	Age and Dosage⁴			
		Under 20, light smoker	23	26	0.88
		Under 20, heavy smoker	37	26	1.42
		20-24, light smokers	25	20	1.25
		heavy smokers	30	20	1.50
		25-34, light smokers	27	23	1.17
		heavy smokers	31	23	1.35
		Over 35, light smokers	44	30	1.47
		heavy smokers	47	30	1.57
		Parity and Dosage⁴			
		0, light smoker	22	21	1.05
		heavy smoker	26	21	1.24
		1, light smoker	23	22	1.04
		heavy smoker	29	22	1.32
		2-3, light smoker	30	24	1.25
		heavy smoker	30	24	1.25
		4+, light smoker	44	30	1.47
		heavy smoker	52	30	1.73
		Class Indicator and Dosage⁴			
		Private Patient			
		light smoker	26	21	1.24
		heavy smoker	27	21	1.29
		Public Hospital Patient			
		light smoker	36	30	1.20
		heavy smoker	52	30	1.73
		Hemoglobin and Dosage⁴			
		± 11 gm/dl			
		light smoker	25	23	1.09
		heavy smoker	28	23	1.22
Niswander & Gordon 1972	189	Race and Dosage⁵			
		white, light smoker	35.0	31.4	1.11
		heavy smoker	37.2	31.4	1.18
		black, light smoker	43.5	38.5	1.13
		heavy smoker	95.2	38.5	2.47
Rush & Kass 1972	216	Race			
		white	31	29	1.07
		black	54	29	1.86
Yerushalmy 1972	282	Race			
		white	11.3	11.0	1.03 ⁶
		black	21.5	17.1	1.26

¹ See Table 3 for more information on each study.

² Social class I is highest.

³ 10 cigarettes or fewer per day or more than 10 cigarettes per day

⁴ Fewer than 20 cigarettes per day or 20 or more cigarettes per day

⁵ Fewer than 20 cigarettes per day and occasional smokers or 20 or more cigarettes per day

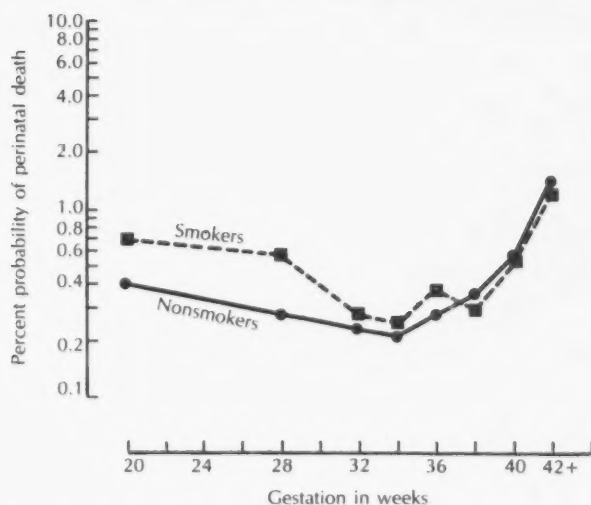
⁶ Neonatal deaths only

nascia found that smokers' pregnancies showed high vulnerability to loss in the earliest weeks; the relative difference tapered off from a doubling of death risk at 20 weeks of gestation to no appreciable difference from 38 weeks on (168). Figure 6 illustrates the probability of perinatal loss for smokers' and nonsmokers' pregnancies, using an initial population of all pregnancies *in utero* at 20 weeks of gestation.

Although birth weight has often been used as a convenient measure of maturity (224), the lower birth weight of smokers' babies is a sign of trouble rather than a cause of it. Low birth weight itself does not explain the higher rates of perinatal mortality among smokers' infants. In fact, in comparisons of mortality rates limited to infants weighing less than 2,500 grams, the smokers' infants survive better (12, 242, 283). Part of the reason for this paradox lies in the fact that the comparison is confined to underweight babies. The nonsmoker's underweight baby is more likely to be small due to shortened gestation period, which can make survival extremely difficult, whereas the smoker's underweight baby is more likely to be gestationally mature (166, 269). This is so even though, looking at all births, a higher percentage of smokers' babies than of nonsmokers' are immature. Thus the rule of thumb that the less an infant weighs, the greater its mortality risk cannot be applied in comparisons like those of smokers' and nonsmokers' offspring, which involve groups that differ in their risks of perinatal mortality (166). A likely explanation of the relationship between birth weight and perinatal mortality is that some of their causes — perhaps shortage of oxygen in particular — may be the same. The oxygen shortage hypothesis is supported by observations of higher perinatal mortality rates at high altitudes, where oxygen is scarce (96, 158).

Pregnancy complications also appear to play a role in tobacco-related perinatal mortality. Each of the complications of pregnancy associated with smoking has been found to be involved in a significantly larger proportion of perinatal deaths for smoking mothers than for nonsmokers. In the Cardiff sur-

Figure 6. Probability of Perinatal Death in Pregnancies of Smokers and Nonsmokers, by Length of Gestation, Ontario Perinatal Mortality Study



Note: Overall probabilities of perinatal death were, for smokers, 2.9 percent (624 deaths in 21,465 births) and, for nonsmokers, 2.3 percent (634 deaths in 27,420 births).

Source: Meyer & Tonascia (168)

Table 6. Perinatal Mortality Rates in Offspring of Smoking and Nonsmoking Mothers, by Education and Antenatal Care, Dacca, Bangladesh, 1977-1978

	Deaths per 1,000 births (numbers in parentheses)		
	Nonsmokers	Smokers	Total
Some education	78.9 (507)	285.7 (7)	81.7 (514)
No education	133.3 (300)	270.0 (100)	167.5 (400)
Total	99.1 (807)	271.0 (107)	119.2 (914)
Some antenatal care	53.6 (261)	400.0 (10)	66.4 (271)
No antenatal care	121.8 (550)	250.0 (100)	141.5 (650)
Total	99.9 (811)	263.6 (110)	119.4 (921)

Note: All differences are statistically significant ($p < 0.01$) except those between smokers with some or no education and between smokers with some or no antenatal care. Mean years of education: 5.6 for nonsmokers; 0.3 for smokers. Mean number of antenatal visits: 1.6 for nonsmokers; 1.2 for smokers.

Source: Begum & Fortney (International Fertility Research Program) (23)

vey, antepartum hemorrhage leading to stillbirth occurred in 0.11 percent of all births to nonsmokers but in 0.39 percent of births to smokers (12). Kullander and Källén found abruptio placentae in 12 of 62 neonatal deaths (19 percent) for smokers but in only 2 of the 58 deaths (3 percent) for nonsmoking mothers, a statistically significant difference (133). French researchers also looked at abruptio placentae cases leading to 13 stillbirths and found that 46 percent of the mothers were smokers as opposed to only 12 percent of the 9,069 women giving birth to live infants (95). Ontario Perinatal Mortality Study data show an unexpectedly high representation of premature membrane rupture, antepartum bleeding, placenta previa, and abruptio placentae among fetal and neonatal deaths of smokers' offspring (168). An estimated 10 percent of all perinatal deaths were attributed to maternal smoking, and placental complications and antepartum bleeding accounted for one-third to one-half of those deaths (167).

Developing Countries

Research in industrialized countries suggests relatively higher risk of perinatal mortality associated with smoking during pregnancy among women with anemia, older women, and women of high parity. These features are common among childbearing women in developing countries. Thus, the incidence of perinatal mortality among women who smoke during pregnancy could be much greater in some parts of the developing world than it is in developed countries. However, there is very little direct evidence from the developing countries on the effects of smoking on pregnancy. In most countries its potential impact can only be indirectly deduced from the prevalence of risk factors known to be present in the population.

Reports from South Asia, including IFRP data, confirm that the impact of tobacco use on the risk of perinatal mortality is indeed greater in developing countries than in industrialized nations. Among women in Dacca, Bangladesh, with no formal schooling, perinatal mortality rates were more than twice as high for smokers (270 per thousand) as for nonsmokers (133 per thousand). Similarly, among women who had had no antenatal care, perinatal mortality rates were more than twice as high for those who smoked (250 per thousand) as for those who did not (122 per thousand) (23) (see Table 6). Most

smokers consumed 1 to 10 hand-rolled cigarettes of strong home-grown tobacco daily. Hemoglobin levels in the smokers, 94 percent of whom were without education, averaged 8.6 grams per 100 ml compared with 9.6 for nonsmokers — both levels that would be classified as anemia (79). Although not conclusive, these IFRP data suggest that for impoverished women with high rates of anemia even light smoking of locally grown products may have a more adverse impact on perinatal mortality than studies in developed countries would predict.

In the Dacca population, 25 percent of the women with no education were smokers. In Maharashtra, India, tobacco chewing was far more prevalent than smoking among pregnant women participating in a maternity hospital study. The exceptions were the two highest social classes, where the habit was totally absent. The stillbirth rate for tobacco chewers was 50 per thousand births, in contrast with 17.1 per thousand for nonusers (131). The study did not control for social class in its reporting of stillbirth rates. However, if all women in the higher, nonchewing classes were eliminated from rate calculations, the stillbirth rate for tobacco chewers would, nonetheless, still be more than 2½ times as great as for the nonchewers. Thus the data so far available suggest that tobacco use may cause higher rates of perinatal mortality in developing countries due to the prevalence of other risk factors.

Anemia may be the single most important consideration. As mentioned, anemia nearly doubles the risk of perinatal death for offspring of women who smoke 20 cigarettes or more daily (169). Although data on the distribution of various nutritional anemias are scarce, the high prevalence of anemia and iron deficiency among pregnant women in the developing countries is widely acknowledged. For example, IFRP data for 1976 and 1977 showed 45 percent of women admitted for delivery in Ibadan to have hemoglobin levels of 10 grams or less per 100 ml of blood (26). A study in seven Latin American countries of nutritional anemia and iron deficiency among women in their last trimester of pregnancy found that 38.5 percent had hemoglobin levels less than 11 grams per 100 ml of blood, the World Health Organization's criterion for anemia (44). Anemia brought about or aggravated by such disorders as hookworm or malaria may also interact with smoking.

Certain vitamin deficiencies may also have important implications for tobacco's effects upon health in pregnancy. Smoking during pregnancy decreases levels of vitamins B₁₂ and C (150, 220). This may in turn affect tissue health. More research is needed to determine if the effect of smoking on vitamin levels reduces the quality and strength of maternal reproductive tract tissues required for a healthy childbirth (259). Because vitamin B₁₂ in particular is usually available only in meat and dairy products, the effects of smoking might be more severe where such vitamin sources are scarce.

Smoking adds especially to the risk of perinatal death in the pregnancies of older women and women who have had three or more children. Data from Quebec show a risk from smoking to high-parity women that is two-thirds greater than the risk to comparable nonsmokers (73). Given the high prevalence of births at high parity and in later years among developing country women, these factors also could mean more risk of perinatal loss. In a number of developing countries, tobacco use is more common in older women (11, 22, 163, 170), perhaps because age and motherhood give them more autonomy. In such cultures, the women most likely to use tobacco would thus be among those whose pregnancies would be most endangered by smoking.

When evaluating the dangers of smoking to pregnancy in developing countries, the limits of health care delivery systems should also be taken into account: less than optimal obstetric and pediatric care further reduces the margin of protection against perinatal mortality (9, 40). In many areas of the developing world obstetric and pediatric facilities are overtaxed or lack the technology needed to save premature infants. The antenatal care important to avert perinatal deaths from maternal toxemia (38) is often lacking as well. As noted previously, the smoking mother whose pregnancy is complicated by toxemia is in greater danger of losing her child than the toxemic nonsmoker. In cases of placental complications, more frequent in smokers than nonsmokers, the woman's life as well as her child's is in danger and is more likely to be lost if skilled care and medical facilities are not available.

INFANT HEALTH AND DEVELOPMENT

For offspring, the health consequences of parental smoking may go beyond the effects of maternal smoking on pregnancy outcome. Breast milk from smoking mothers, prolonged exposure to tobacco smoke in the home, and the latent or lingering effects of exposure during gestation may adversely affect the health of smokers' children. Children whose parents smoke are also more likely to take up smoking at an early age themselves.

Congenital Malformations

Although a cause-and-effect relationship between smoking during pregnancy and congenital malformations has not been established, fragmentary evidence suggests that further study may be worthwhile. One indication of physical abnormalities comes from the laboratory research of I. Asmussen in Denmark, who has studied the tissues of umbilical arteries and veins from infants of smoking and nonsmoking women. Her investigations reveal severe vascular damage in the specimens from smokers, suggesting similar changes in the blood vessels of their newborn children (16, 17). The inner walls of umbilical arteries from pregnant smokers showed surfaces with an abnormal "cobblestone appearance," a pattern that was more irregular in mothers who smoked more than 20 cigarettes per day than in light smokers (17). Asmussen hypothesizes that such damage could lead to coronary heart disease later if present in the newborn (17).

Epidemiologic studies designed to find a relationship between smoking and congenital malformations often suggest an association between smoking and birth defects but do not point consistently to the same malformations. A recent study in Connecticut (USA) involving 1,370 births of abnormal infants and 2,968 controls found a 10 percent increase in risk of malformations in the infants of women who smoked more than 10 cigarettes daily; risk rose with cigarette consumption, reaching a 90 percent difference in risk for smokers of more than 30 cigarettes a day. Increased risks were estimated to be highest for pyloric stenosis, digestive tract abnormalities, and inguinal hernia, but the researchers concluded that there was a general elevation in risk of all malformations rather than one specific to certain malformations (126).

Data from the British Perinatal Mortality Survey show a higher incidence of congenital heart disease in smokers' children — 7.3 per thousand births compared with 4.7 per thousand in

nonsmokers' babies (75). The Child Health and Development Study of Oakland, however, found no increase in congenital heart disease among smokers' children (281). Naeye's study of perinatal deaths in the Collaborative Perinatal Project discerned a much higher frequency of anencephaly (failure of the brain to develop) among smokers of more than 10 cigarettes per day (185). Cardiff Births Survey results do not produce evidence of increased anencephaly among smokers' births, but the total incidence of abnormalities is significantly higher among smokers' infants (12). Data on congenital abnormalities among live births derived from a mail survey of US female medical specialists found a significantly higher rate of abnormalities reported by smokers in all 5-year age groups. Differences between smokers' and nonsmokers' abnormality rates for cardiovascular, urogenital, and gastrointestinal defects were the least likely to be due to chance (111). Other studies examining the possibility of a relationship between tobacco use and birth defects have found none (18, 43, 133, 223, 301).

Lactation

Smoking during lactation may reduce the quality of breast milk, by introducing undesirable chemicals, and, perhaps, also reduce the quantity a mother is able to produce.

If mothers smoke during lactation, their milk contains nicotine that is passed along to their infants (209, 266). A lactating mother smoking over 20 cigarettes daily could in rare cases cause nausea, diarrhea, and vomiting in her infant (266). The observation that smoking mothers excrete tobacco smoke components in their breast milk was first made over 50 years ago (104), but modern agricultural practice has since added another possible risk to such a transfer of chemicals: the lactating mother who smokes passes along more DDT to her infant than the nonsmoking mother. A study of 55 human milk samples, 10 of them from smokers, showed significantly higher levels of DDT in smokers' milk, levels which rose with amount smoked. The researchers were unable to determine whether the increased DDT came from tobacco, from other sources in the mothers' bodies, or from a combination of both (33).

In laboratory studies of rats, nicotine has reduced milk production by blocking the release of prolactin (30). P. Underwood and colleagues, reporting on 4,440 histories of breast-feeding in first pregnancy, found higher percentages of smokers than of nonsmokers claiming inadequate milk in two of three socioeconomic groups studied. The differences did not attain statistical significance, however (241). The 1979 US Surgeon General's report cites anecdotal evidence of smoking interfering with milk production and notes the need for studies of larger populations of smoking and nonsmoking women (259).

Table 7. Infant Pneumonia and Bronchitis, by Parents' Smoking Habits, London, 1963-1969

Parental Smoking Habit	No. of Cases	Annual Incidence per 100 Children
Both nonsmokers	372	7.8
One smoker	552	11.4
Both smokers	478	17.6
Both or either exsmokers, or habit changed	675	9.2
All	2,077	11.5

Source: Colley et al. (42)

Health Problems in the First Year of Life

The smoking habit of both parents can damage the health of infants by exposing them to tobacco smoke in the home. The involuntary inhalation of tobacco smoke has become a prominent concern in the United States and other Western countries as evidence has accumulated that tobacco smoke can affect the health of bystanders (97).

Research points to higher rates of bronchial illnesses in the infants of smokers. In a West Jerusalem study of 10,672 infants, rates of hospital admission for bronchitis and pneumonia were significantly higher for infants under one year of age whose mothers smoked than for infants of nonsmokers — 13.1 cases per 100 infants compared with 9.1. The rate of admissions was positively associated with the number of cigarettes smoked by the mother (102). A London study of 2,077 infants in the first five years of life found a significant relationship between parental smoking habits and infant bronchitis and pneumonia. The association was strongest when both parents smoked, lowest for nonsmoking parents, and intermediate when one parent smoked (see Table 7). These ill effects appear to be most acute during the first year of life: while parental cigarette smoking was associated with a twofold increase in the incidence of bronchial infection during the first year, it was not consistently associated with this ailment after the age of one year (42).

Smoking has been implicated in Sudden Infant Death Syndrome (SIDS, or SUD, Sudden Unexpected Death), an as-yet-unexplained phenomenon that typically involves pulmonary inflammation but insufficient pathological evidence to account for death (230). Comparing 125 cases of SIDS in the Collaborative Perinatal Project with 375 matched controls, Naeye and colleagues found that maternal smoking was more prevalent during the gestation of the SIDS babies (59 percent of SIDS mothers, 48 percent of controls). Some 46 percent of the SIDS mothers smoked six or more cigarettes a day whereas only 25 percent of the controls did. Both differences attained statistical significance. The researchers noted that a larger proportion of SIDS victims than of controls was mildly underweight for gestational age (186). A Seattle study of 56 SIDS families found that a greater proportion of the mothers smoked both before and after delivery than did the mothers in the 86 control families. While 61 percent of the SIDS mothers smoked during pregnancy, only 42 percent of controls did, and after birth the percentages of mothers smoking were 59 and 37, respectively. The differences were statistically significant. In addition, SIDS mothers smoked a greater number of cigarettes than the controls (25). A Canadian investigation of 66 families experiencing sudden infant death also discovered that the cases' mothers were more likely to have smoked during pregnancy than were controls' (230).

Subsequent Development

Children of smokers may run a risk of being slightly physically and intellectually disadvantaged in comparison with children of nonsmokers. In their physical development, children of women who smoked during pregnancy have failed to attain the height for age of nonsmokers' children. At ages five (273), six-and-one-half (63), and seven (92), the heights of smokers' children averaged about one centimeter less than nonsmokers'. Not all of these differences proved statistically significant; J.B. Hardy and E.D. Mellits, on the basis of their study of 143 pairs of smokers' and nonsmokers' children, rejected the possibility of long-term effects (101). The direction of the results of all of these studies of growth, however, is consistent. Analysis of data from the British National Child Development Study



A Trobriand Island woman smoking a homemade, leaf-wrapped cigarette. (Richard Harrington/Camera Press)

suggests that long-lasting effects of smoking on growth may not be solely the result of low birth weight; after controlling the data of 7-year-olds for birth weight researchers found that an average difference in height of 1.0 cm between smokers' and nonsmokers' children persisted (92).

Some researchers suggest that deficient neurological and intellectual development of offspring may be associated with smoking during pregnancy (39, 52, 64, 188). The British National Child Development Study provides the largest body of cohort data, with follow-up at ages 7 and 11 of several thousand children of smoking women (39, 52). After allowance was made for six other factors, 7-year-old children of mothers who had smoked 10 or more cigarettes a day during pregnancy were four months behind nonsmokers' children in reading ability. Of the seven factors, social class, birth order, number of younger siblings, the sex of the child, and birth weight, in that order, had more effect upon reading ability than smoking, and the age of the mother had less effect (52). At the age of 11, the children of heavier smokers (10 or more cigarettes per day) were tested again, this time for reading, mathematics, and "general ability." They fell behind children born to nonsmoking women by 4, 5, and 3 months in each of the areas, respectively (39). The researchers, while noting that such factors as number of children in the household could influence results by as much as 16 months and that smoking-associated personality factors were not taken into account, nevertheless suggested that parental smoking is an independent factor in intellectual development (39).

Extreme caution is required in interpreting these findings on intelligence, because many environmental factors shape a

child's intellectual development, among them parental behavior patterns that may also be related to smoking (64). Longitudinal studies of intelligence are especially difficult, not only because selection of the variables to be measured must anticipate such confounding factors, but also because changes occur in the child's environment during the long course of the project (59). Nevertheless, should children be impaired, however slightly, by smoking during pregnancy, the consequences for human development would be far reaching; the possibility makes further study important.

Smoking parents endanger their children's health by their example as well as by their behavior: the children of smokers are more likely than the children of nonsmokers to take up smoking themselves (254, 302). In a US survey, in homes where both parents smoked teenage boys were twice as likely to smoke and girls were almost three times as likely to smoke as in homes where neither parent smoked (253). In a survey in Rochester, New York, girls again proved particularly 'influenced by parental smoking. For both sexes, both parents smoking had a stronger influence than only one parent smoking. The youngest smokers were the most likely to imitate their parents. White girls under age 15 were five times as likely to smoke if both their parents smoked than if neither parent smoked. Boys under age 15 were twice as likely (302).

Young smokers like these exhibit the symptoms of smoking early. English children aged 10 to 12½ who smoked were more likely to cough than nonsmokers even though most smoked an average of fewer than one cigarette a day (288, 289). The secondary school students in Rochester, an older group, exhibited respiratory symptoms increasingly with the amount they smoked. Heavy smokers (15 or more cigarettes a day) reported coughing on arising at 10 times the rate of nonsmokers, and cough and phlegm were more chronic in heavier smokers (215, 302).

TOBACCO AND OTHER ASPECTS OF REPRODUCTION

While research has focussed on the effects of tobacco use on the health of the pregnant woman and her offspring, there is also evidence that smoking may affect other aspects of male and female reproductive health as well. Smoking may bring on menopause at an earlier age. Smoking and oral contraceptive use combined markedly increases the risk of developing certain vascular diseases. The possibility of links between tobacco and cervical cancer deserves further investigation. It has also been suggested although not proved that sperm quality may be adversely affected by tobacco use.

Menopause

Earlier menopause due to smoking, first seen in small studies (49), has recently been confirmed in two large-scale studies. In 1977, H. Jick and colleagues reported an association between smoking and early age of natural menopause in two large sets of data, one covering 2,143 patients, aged 44 to 53, in Boston-area hospitals, the other covering 1,391 patients in the same age group from hospitals in seven countries. The data from Boston and from each of the seven countries showed greater percentages of smokers than nonsmokers among the post-menopausal in each two-year age group between 44 and 53.

Table 8. Age-standardized Proportions of Postmenopausal Women Aged 44-53, by Smoking Status

Smoking Status	Boston Hospital Study		Seven Country Hospital Study	
	No. of Women	% Menopausal	No. of Women	% Menopausal
Never smoked	921	35	697	53
Ex-smoker	301	36	138	59
10 cigarettes/day	216	43	190	60
20 or more cigarettes/day	705	49	366	65
Total	2,143		1,391	

Source: Jick et al. (120)

Furthermore, age-standardized groupings of women by smoking status in both data sets revealed that the percentage of postmenopausal women increased with the amount smoked: ex-smokers ranked between nonsmokers and smokers of 10 cigarettes or more per day (120) (see Table 8). A Swedish study of a randomly drawn sample of women aged 46, 50, and 54 found a significantly higher percentage of smokers among 50-year-old postmenopausal than among premenopausal women. Similar but not significant trends were seen in 46- and 54-year-old groups (141). In both of these studies, the researchers were able to reject the possibility that the women in their samples began smoking as a result of menopause. To explain the association between smoking and earlier menopause, both research groups point to steroid metabolism: smoking might increase the liver's metabolism of estrogens; thus smokers might experience an earlier fall in estrogen levels that in turn brings on menopause (120, 141). Another possible explanation is suggested by recent research showing that benzo(a)-pyrene, one of the carcinogenic ingredients in tobacco smoke, destroyed oocytes in the ovaries of mice; the menopause in humans occurs as the ovarian stores of oocytes are depleted, and a similar process might be operating in women who smoke (155). One other hypothesis involves amount of body fat: noting that studies have found a higher incidence of obesity among nonsmokers and later menopause among obese women, H.W. Daniell examined data for 500 women interviewed in his private practice. He found that some but not all of the difference in average age at menopause was due to differences in weight between the smokers and the nonsmokers (49).

Contraception and Conception

The effects of tobacco on the circulatory system in women have received new attention as a result of research on the safety of oral contraceptives (OCs). Both case-comparison and cohort studies show that women who smoke and at the same time use oral contraceptives face an increased risk of cardiovascular and cerebrovascular disease, especially myocardial infarction and subarachnoid hemorrhage (119, 193, 199, 214, 263). Further, using OCs and smoking may not merely combine independent risks, but in fact multiply the risks so that women who use OCs and smoke may face a risk of circulatory system disease as high as 10 to 20 times that of nonsmokers who do not use OCs (81, 193, 199). Older age (over 35) and other predisposing factors add still further to the risk. Thus women, who normally seem to be at lower risk than men for tobacco-induced heart disease, may face equal or even higher risk if

they use oral contraceptives. (An extensive review of current research on oral contraceptives and smoking is provided in *Population Reports* A-5, January 1979.)

In the course of research on the fertility of almost 2,000 women after they discontinued using oral contraceptives, diaphragms, and other contraceptive methods, M. Vessey and colleagues found an indication of reduced fertility (indicated by a longer average interval between stopping contraceptive use and giving birth) among women who smoked 15 or more cigarettes daily (264), but the effect was very weak (279). In the Jerusalem Perinatal Study, involving a larger sample, no such effect was seen, regardless of number of cigarettes smoked (103).

The possibility that smoking increases the chances of cancer of the reproductive organs is also now receiving attention. Analysis of (US) Third National Cancer Survey data by R.R. Williams and J.W. Horm revealed a statistically significant association between invasive cancer of the uterine cervix and cigarette smoking, with rates increasing as cigarette consumption increased (270). A smaller study conducted in 1963 also found an association with smoking. Although no dose-response relationship was seen, those who had stopped smoking had a rate of histologically confirmed cases of cervical neoplasia lower than for current smokers but higher than for those who had never smoked (187). In neither study, however, were the researchers able to control for differences in sexual behavior, especially age at first coitus, that are known to affect risk of cervical cancer and may also be linked to cigarette consumption (204). In a study of 324 cases showing cytological signs of cervical neoplasia and 302 controls, the researcher found the association between cigarette smoking and cervical carcinoma *in situ*, the predecessor of invasive cancer, to be of "borderline significance." The research design controlled for 13 possible confounding variables, among them premarital conception of first child and first pregnancy before age 20, but age at first coitus was not included (237).

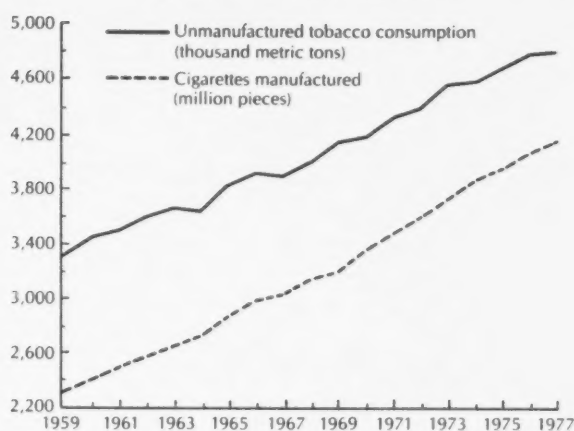
Male Fertility

Much of the early research on the health effects of tobacco focussed on males because at the time only males smoked extensively, but there has been little attention paid to the possible impact of tobacco use on male reproductive capacity. Research in Budapest on 120 smokers and 50 nonsmoking controls discerned a reduction in the proportion of motile sperm for smokers that was related to number of cigarettes smoked: men smoking more than 30 cigarettes a day showed 49 percent motile sperm; men smoking 10 or fewer cigarettes a day, 57 percent; and controls, 69 percent. The incidence of deformed sperm was significantly greater among the men who smoked the most and for the longest periods of time (265). Since the researcher chose the smokers from a group of men being treated for sexual, hormonal, or reproductive disorders,

"Tobacco, divine, rare, superexcellent tobacco, which goes far beyond all the panaceas, potable gold, and philosopher's stones, a sovereign remedy to all diseases . . . but as it is commonly abused by most men, which take it as tinkers do ale, 'tis a plague, a mischief, a violent purger of goods, lands, health, hellish, devilish and damned tobacco, the ruin and overthrow of body and soul."

Robert Burton (1577-1640)

Figure 7.
World Unmanufactured Tobacco Consumption and
Cigarette Production, 1959-1977



Source: US Department of Agriculture (247)

both the validity of the results and their applicability to a healthy male population are questionable, however.

In similar research conducted in Prague, semen from 429 men was classified as of normal sperm quality, of reduced sperm concentration, or azoospermic. The proportion of heavy smokers (20 or more cigarettes a day) rose as sperm concentrations fell: 9.5 percent of the men with normal sperm were heavy smokers, as were 12.5 percent of those with reduced sperm counts and 15.5 percent of those whose semen was classified azoospermic (204). All the men were examined because their marriages were infertile. Research that studies the sperm of large groups of smokers and nonsmokers who are not selected for possible fertility problems will be needed to determine more clearly whether smoking has an effect on sperm.

An Australian study found levels of plasma testosterone 16 to 47 percent lower in six healthy male smokers of 30 or more cigarettes a day than among their individually matched nonsmoking controls. After seven days of refraining from smoking, all of the smokers' testosterone levels rose significantly (35). Whether low testosterone levels mean lower fecundity is not known (231). As a rule, testosterone levels must be severely lowered before any appreciable effects on sperm production occur (69). Men being treated for various illnesses, among them infertility, have reported increased sexual activity after giving up smoking (191, 235), but comparable studies have not been undertaken with a normal, healthy population. Since human sexuality involves a large number of physical and psychological variables, conclusions based on these limited observations would be unwarranted. Even if tobacco lowers testosterone levels appreciably, there is no clear-cut relationship between sexual drive and testosterone concentration that would permit predictions of sexual behavior (69, 231).

The cancers of male reproductive organs were not significantly associated with tobacco use in the Third National Cancer Survey. A "suggestive" association appeared, however, between cancer of the testis and all forms of tobacco use other than cigarette smoking (270).

With the exception of data on earlier menopause and on oral contraceptives, the information on the involvement of tobacco use with aspects of reproductive health other than pregnancy

and childbearing does not yet lead to conclusions. It does, however, suggest the need for further research on a wide variety of issues involving smoking and reproductive and sexual health.

WORLDWIDE USE OF TOBACCO

Despite mounting evidence of the health hazards of tobacco use, the worldwide growth, manufacture, and use of tobacco are increasing. An estimated 4.9 million metric tons (dry weight) were produced in 1977 (247). Although this was a slight decrease from the record 5 million ton yield of the year before, the manufacture of cigarettes increased, despite rising cigarette prices in many countries (246). The increase in cigarette manufacturing continues long-term trends toward more tobacco consumption, both in absolute amount (see Figure 7) and per capita (see Table 9).

Tobacco production is increasing more rapidly in the developing world than in the industrialized countries. Data from the

Table 9. Annual Cigarette Consumption Per Person
Aged 15 and Older, Selected Countries, 1935, 1950,
1965, and 1973

Developed Countries	Consumption Per Adult			
	1935	1950	1965	1973
Australia ^a	450	1,280	2,680	3,080
Canada ^a	700	1,790	3,310	3,450
Denmark	470	1,290	1,500	1,850
France	530	930	1,510	1,920
West Germany	—	630	2,100	2,610
Japan	880	1,220	2,350	3,240
Sweden	380	810	1,360	1,580
United Kingdom	1,590	2,180	2,680	3,230
United States	1,450	3,240	3,800	3,850
Developing Countries				
Argentina	1,060 ^b	1,460	1,660	1,940
Barbados	—	—	1,110	1,620
Brazil	600 ^c	1,140	1,220	1,490
Chile	—	—	1,220	1,320
Costa Rica	—	—	1,850	2,060
El Salvador	—	—	750	1,020
Ghana	—	—	480	480
Hong Kong	—	—	3,310	2,780
India	80 ^d	100	180	170
Indonesia	—	—	—	230
Jamaica	—	—	1,270	1,350
Kenya	—	—	390	470
Malawi	—	—	150	200
Malaysia	—	—	1,440	1,600
Mauritius	—	—	1,610	1,920
Mexico	1,440	1,510	1,510	1,360
Morocco	240	510	570	690 ^e
Nicaragua	—	—	1,140	1,520
Pakistan	—	—	450	760
Sierra Leone	—	—	280	430
Singapore	—	—	2,380	2,490
Turkey	960	1,220	1,820	2,050 ^e
Venezuela	—	—	1,900	2,210

^a Handrolled cigarettes not included; add about 10 percent to total consumption.

^b Figures are for Year 1940.

^c Annual averages for 1935-1939.

^d Figures are for Year 1948.

^e Figures are for Year 1972.

Source: Lee (135)

UN Food and Agriculture Organization show that tobacco production in the developing world rose by 28 percent between 1969-1971 and 1977, while in the developed countries it rose 15 percent (243). In 1977, some 60 percent of the world's tobacco was grown in the developing world, up from 57 percent in 1969-1971 (243). In a recent four-year period, the number of cigarettes manufactured in eight major producing nations of the developing world rose by about 12.7 percent, while in five major industrialized producer nations it rose only 2.4 percent (243) (see Table 10). Of the world's top 10 tobacco producers, six are in the developing world — China, India, Brazil, Turkey, Korea, and Indonesia (see Table 11).

With the important exception of China, most of the developing countries are increasing the acreage allotted to tobacco, both for domestic consumption and for export. China, the world's largest producer, raised almost 900,000 metric tons in 1977 but exported only 35,000 metric tons, or about 4 percent. Of the production of the next 10 tobacco-raising developing countries, over 500,000 metric tons, or about one-third, were exported. The rest was used for domestic consumption, which is now increasing by about 5 percent annually (247).

Among developed countries, the United States is by far the largest exporter — as well as consumer — of tobacco, and US exports are growing. In 1977, the United States exported a record high \$1.73 billion worth of tobacco and tobacco products — about one-third of the US crop. Of these exports, approximately two-thirds went to Europe, Japan, Hong Kong, and the Middle East, but there is increasing demand in the developing world for the high quality, flue-cured US tobaccos to blend with indigenous strains.

The statistics on tobacco production, import, and export can be used to suggest national levels of tobacco consumption.

Table 10. Estimated Number of Cigarettes Manufactured by Selected Major Producers, 1974 and 1977

	Output (in million pieces)		Percent Change
	1974	1977	
Developed Countries			
Germany, F.R.	139,842	137,000	-2.0
Japan	292,157	297,000	1.7
Soviet Union	371,000	380,000	2.4
United Kingdom	158,809	154,625	-2.6
United States	635,000	665,871	4.9
Total	1,596,808	1,634,496	2.4
Developing Countries			
Brazil	100,329	129,000	28.6
China	671,000	729,000	8.0
India	62,400	67,807	8.7
Indonesia	49,907	64,827	29.9
Korea, South	49,323	60,000	21.6
Mexico	43,125	47,500	10.1
Philippines	41,453	51,373	23.9
Turkey	54,433	58,200	6.9
Total	1,071,970	1,207,707	12.7
World Total	3,849,656	4,126,452	7.2

Source: US Department of Agriculture (246)

However, not all the tobacco consumed in developing areas is in commercially prepared form. Much of it is grown in backyard plots and so is not reflected in marketing statistics. In Latin America, however, home tobacco gardens have begun to disappear as commercial channels for cigarette marketing have developed, a process that may be repeated elsewhere (233). Such a shift means that meager cash incomes may be increasingly diverted to tobacco from other, more essential purchases.

Table 11. Tobacco Production and Consumption in Major Developed and Developing Producer Countries, 1960, 1970, 1977 (in thousand metric tons dry weight)

	1960		1970		1977		Change in Area Harvested 1960-1977 ^a
Developed	Prod.	Cons.	Prod.	Cons.	Prod.	Cons.	
* United States	805	714	780	625	782	604	-
Soviet Union	160	226	233	299	270	361	+
Japan	109	124	135	192	156	220	S
* Bulgaria	56	14	110	55	135	78	S
* Canada	87	50	91	66	94	80	S
* Italy	61	62	67	76	92	75	+
Poland	37	44	77	69	85	91	+
* Yugoslavia	25	23	44	32	58	44	+
Developing							
China	592	538	694	733	878	877	S
* India	274	259	317	283	389	314	+
* Brazil	133	96	174	101	272	165	+
* Turkey	118	34	130	47	206	68	+
* Korea, South	27	28	53	53	134	54	+
* Indonesia	63	57	93	48	110	75	S
* Greece	59	12	81	17	107	24	+
* Argentina	41	40	66	51	90	66	+
* Philippines	60	25	93	48	78	73	+
* Pakistan			80 ^b	85 ^b	69	59	
* Thailand	26	25	41	40	65	54	+
Burma	34	41	31	45	64	66	S
* Mexico	39	38	57	43	59	43	S
Bangladesh			30 ^b	35 ^b	54	52	

* = Net exporter, 1977

^a Change in area harvested is designated by S = no change, + = an increase, - = a decrease.

^b 1972 data

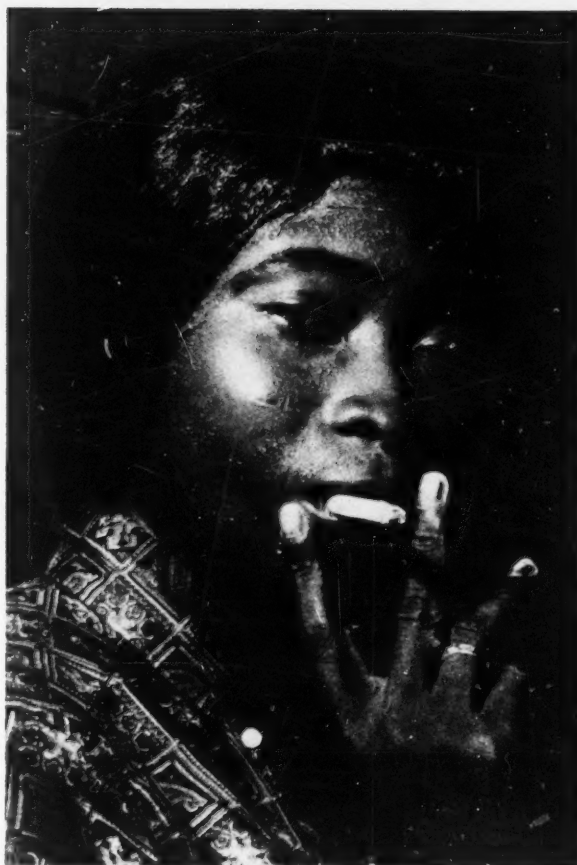
Source: US Department of Agriculture (247)

Generally speaking, a country's level of tobacco consumption reflects the affluence of its people (65, 194). Thus, while per capita consumption in the developing world is less than in developed countries (see Table 9), it can be expected to rise wherever economic development occurs, since development creates both discretionary cash income for the purchase of cigarettes and the channels of communication and commerce through which tobacco can be further promoted and distributed. Also, population growth in the developing countries has created a large potential market of young adults. A tobacco industry analyst in the US has noted that the so-called world market for the industry is five times as large as the US market and is growing over 2.5 times as fast (194).

Three of the top five cigarette producers are government monopolies, in China, the Soviet Union, and Japan, but in the rest of the world the large private multinational companies such as the British-American Tobacco Company, R.J. Reynolds, and Philip Morris Inc. have not been slow to see opportunities for growth in the developing countries. Whereas restrictions and educational efforts in developed countries have forced them to spend more and more on advertising merely to maintain existing consumption levels, such barriers are still absent in most developing nations (65, 116, 194). Tobacco companies are taking advantage of this relative freedom. In Kenya, for example, the nation's only cigarette company is its fourth largest advertiser. The promotion appears to be successful: cigarette consumption is growing at a rate of 5 to 10 percent per year (179).

The patterns of tobacco use in the developing world resemble those of other Western consumer products. Latin American countries generally have the highest rates of tobacco use, whereas the countries of Africa have the lowest (65, 135). Use rates in much of Asia are intermediate. The differences are partly the result of lower levels of discretionary spending in Africa and much of Asia (65). Smoking is more prevalent in urban than in rural areas (22, 65), perhaps partly because cash incomes are higher in the cities (179). Also, smoking is being taken up by those who are better educated and have higher incomes (65). In many developing countries smoking is more common among college and university students than among nonstudents, and more students become smokers as they proceed through school (14, 20). The increase in smoking by the well-off and well-educated may encourage its spread to the rest of the population, since advertising campaigns in these countries play upon people's desire to imitate their own elites, just as advertising in the West once played up cigarettes as a symbol of sophistication and high social status (65, 179).

Ironically, while smoking is spreading in the developing countries, and most rapidly among the elites, smoking is decreasing in the US and UK, with the sharpest declines occurring among the best educated. The biggest downturn in smoking rates in the US followed the US Surgeon General's report on the health hazards of smoking in 1964 (258). Between then and 1970 smoking among men dropped from 52 to 42 percent and, among women, from 34 to 30 percent (255); between 1970 and 1975 there was a further decrease to 39 percent by men and 29 percent by women (256). In the US a smaller than average proportion of well-educated men are smokers — in 1975 some 28 percent of male college graduates (256). In the UK cigarette smoking by men dropped off sharply after the 1962 publication of the Royal College of Physicians' report, *Smoking and Health*. The higher a man's social class, the more likely he is to have given up smoking (179, 214). Less smoking



A woman smoking a cigarette may become an increasingly common sight in Africa. (Paul Almasy/Camera Press)

among the better-educated has been noted in other developed countries as well (204, 277).

Smoking by Women

Women are less likely to smoke than men. However, sales to young women are increasing in many places (277). In the US, despite an overall decrease in smoking, the proportion of females in their teens who smoked nearly doubled between 1968 and 1974, when it reached more than 15 percent (253). US cigarette advertising aims at women's desire to express their independence and their equality with men. The appeal is ironic, coming at a time when more men are refraining from smoking.

In general, a smaller proportion of women smoke in developing countries than in industrialized nations. Rates vary greatly, however, not only from country to country, but from one ethnic or religious group to another. Over one-fourth of women surveyed in Santiago, Chile, and Caracas, Venezuela, reported smoking, but only 10 percent in Guatemala City and 7 percent in Lima, Peru (121). A survey of almost 25,800 women in India found 41.0 percent using tobacco in some form, with proportions ranging from 14.9 percent to 67.2 percent in the five areas studied (161). In rural Goa, 54 percent of Hindu women and 34 percent of Christian women were found either to smoke or to chew tobacco (28), and a survey in Papua New Guinea reported smoking — mostly of cigars made of locally grown tobacco — to be almost universal among women over age 25, as it was among men (11). By contrast, in urban Sri

Table 12. Rates of Tobacco Use, Selected Countries, 1963-1978

Author & Date	Ref. No.	Location and Population	Percent Current Tobacco Users	
			Male	Female
Africa				
Arya & Fowkes 1971	286	Kampala, Uganda: Makerere University Students, survey, 1970	29.8	5.0
		Non-academic staff, survey, 1971	35.0	5.8
		Kasangati region, Uganda: 4 villages, inhabitants aged 16 years and older, survey, 1971	38.6	18.0
Baylet et al. 1974	22	Niakhar, Senegal: residents of 65 rural villages and migran.ts to urban area		
		Rural Urban	47.2 55.6	11.6 3.1
Elegbeye & Femi-Pearse 1976	68	Lagos, Nigeria: children in secondary schools and medical students at Lagos University, surveys		
		Secondary school students	40.0	8.4
		Medical students	72.4	22.2
Schonland & Bradshaw 1969	219	Durban, South Africa: hospital inpatients, survey, 1964-1966		
		African Indian	63.9 56.2	3.6 7.8
Asia				
Anderson 1974	11	Papua New Guinea: 3 rural villages on Karkar Island, inhabitants aged 10 and older, survey	97.0	95.3
Banerjee 1963	20	Calcutta, India: students at colleges, 1962-1963	—— 26 ——	
Bard & Peacock 1976	21	Hong Kong: university students, staff, and staff dependents, cohort study, 1971-1975		
		Senior year students	19.2	6.5
		Staff (aged 17-24)	24.0	2.0
Bhonsle et al. 1976	28	Goa, India: 11 villages, inhabitants aged 15 and over, survey		
		Hindus	74	54 ^a
		Christians	52	34
Leung 1977	295	Hong Kong: selected adults, survey	59.0	11.0
Malik et al. 1977	296	Chandigarh, India: hospital visitors, adults, survey	25.6	0.13
Mehta et al. 1969	161	India: rural villages in 5 districts, inhabitants aged 15 years and older, survey		
		Gujarat	70.9	14.9
		Kerala	81.2	38.8
		Andhra Pradesh	80.6	67.1
		Singbhum	80.9	32.6
Darbhanga	78.1	51.4		

Continued on next page

Lanka only 1.6 percent of females questioned reported smoking (260). Few Moslem women smoke; in Pakistan, for example, only 2 percent of smokers are female (179). (See Table 12.)

Women who use tobacco appear to favor traditional forms more than men do. Most of the evidence for this comes from India and Sri Lanka (28, 161, 260), but the same pattern has been reported from Papua New Guinea (11). In F.S. Mehta and colleagues' study of smoking in five areas of India, for example, only between 0.4 and 5.2 percent of all women smoked conventional cigarettes in four of the areas, while from 14.5 to 62.2 percent used tobacco in some traditional form. In the fifth area, however, 41.0 percent smoked conventional cigarettes. Wide variations in traditional practices also were observed. In the Singbhum district of Bihar almost 26 percent of women chewed tobacco, compared with less than 3 percent in Andhra Pradesh. But in Andhra Pradesh 56.6 percent of all women smoked *chutta*, a cigar of coarse tobacco rolled in tobacco leaf or the leaf of the *temburni* tree (127), with the lighted end held inside the mouth to keep it burning. In Singbhum, by contrast, no women smoked *chutta* in reverse (161). The hazards of traditional forms of tobacco use are not well quantified, but

they apparently vary with the type of tobacco and the way it is used.

Surveys may underestimate smoking among women. In more traditional communities social pressures discourage women from smoking in public and may lead them to conceal smoking from interviewers (233). Also, traditional forms of tobacco use, including chewing tobacco and smoking locally made cigarettes like *bidi*, may be excluded from or underreported in surveys (79, 260).

Concern about women's smoking focuses not just on individual well-being, but also on the special implications of smoking for reproduction. The US government estimates that 20 to 25 percent of US females smoke during pregnancy (257). Other studies have found rates as high as nearly 50 percent (37, 189, 216) (see Table 13). A comparison of data for women under 25 years of age in the British Perinatal Mortality Survey of 1958 and the Cardiff Births Survey of 10 years later reveals a 50 percent increase in smoking by pregnant women during the decade. In the later study about 45 percent of pregnant women under 25 smoked (12). Studies in Ontario and Quebec,

Table 12 (Continued)

Table 12. Rates of Tobacco Use, Selected Countries, 1963-1978

Author & Date	Ref. No.	Location and Population	Percent Current Tobacco Users	
			Male	Female
Pathmanathan 1974	298	Malaysia: 4 villages in the Negri Sembilan region, inhabitants aged 15 years and older, survey, 1973	56.0	20.5
Pathmanathan 1975	195	Malaysia: University of Malaya medical students, survey, 1972	25.5	1.6
Sehgal et al. 1971	303	Chandigarh, India: urban residents, survey	28.3	
Toda et al. survey, 1968	305	Surabaya City, Indonesia: health center patients, children and adults,	14.8 ^a	1.5 ^a
Uragoda & Senewiratne 1971	260	Kandy, Sri Lanka: residents aged 15 and over, random sample, 1969	48.2	1.6
Latin America				
Joly 1975	121	Bogota, Colombia: urban residents aged 15-74, stratified sample, 1972	52	21
		Caracas, Venezuela: as above	49	26
		Guatemala City, Guatemala: as above	36	10
		La Plata, Argentina: as above	58	24
		Lima, Peru: as above	48	4
		Mexico City, Mexico: as above	45	17
		Santiago, Chile: as above	47	26
		Sao Paulo, Brazil: as above	54	20
Miller 1974	170	Guyana: all residents aged 35-54 in two adjacent rural villages, survey, 1968	48	4
		Suburb of Kingston, Jamaica: inhabitants aged 15-65, random sample, 1969-1970	56.1	13.9
Developed Countries				
Lee 1976	134	United Kingdom, individuals aged 16 and over, modified quota sample, 1975	61.5	43.4
US Dept. of Health, Education, and Welfare 1976	256	United States, individuals aged 21 and over, random sample, 1975	39.3	28.9
US Dept. of Health, Education, and Welfare 1979	259	United States, individuals aged 17 and over, Health Interview Survey, 1978	37.5	29.6

^aThree-fourths were tobacco chewers.^b20 or more cigarettes a day

Canada, in the early 1970s found about 43 percent of pregnant women smoking (73, 169).

Smoking during pregnancy already seems to be a problem in Latin America. The large samples of the International Fertility Research Program's Maternity Care Monitoring program suggest that over 20 percent of urban pregnant women are smoking in Latin America compared with 1.6 percent in developing areas of Asia and 0.2 percent in the Middle East and Africa (79). Other studies, of smaller groups, show 20 percent smoking in Caracas, Venezuela (128), and 25 percent among 500 illiterate women in Dacca, Bangladesh (23), but under 2 percent in two locations in India (131, 175) (see Table 13).

K. Krishna's report that over 15 percent of women giving birth in a Delhi hospital chewed tobacco, while less than one percent smoked, suggests that more emphasis needs to be placed on the study of traditional forms of tobacco use in much of the world. For the pregnant woman, the full implications of chewing tobacco rather than smoking are not clear, since it is not certain which components of tobacco smoke are associated with which effects on reproductive health. Krishna observed a

higher stillbirth rate and lower average birth weight among the offspring of women who chewed tobacco (131), and nicotine in chewing gum has been reported to alter fetal breathing movements temporarily (90). Further examination of the effects of chewing tobacco on reproductive health appears warranted, and the findings may be of special interest in developing countries.

Variations in Exposure

The form and manner in which tobacco is used determine exposure to tobacco components and, thus, the degree of risk to its user's health. In this regard, probably the most important trend in smoking practices is the shift in developing countries towards smoking commercial cigarettes and away from traditional forms of tobacco use like chewing tobacco, smoking through a water pipe, or smoking hand-rolled cigarettes or cigars of strong local tobacco.

On one hand, this shift offers some health advantages because US tobaccos, for instance, have a lower tar and nicotine content. Western tobaccos are somewhat milder, have fewer im-

Table 13. Percentage of Women Using Tobacco During Pregnancy in Various Areas, Selected Studies, 1969-1979

Author & Date ^a	Ref. No.	Area	Percent Smoking
Developed Areas			
Andrews & McGarry 1972	12	Cardiff, Wales, UK	42.7
Butler et al. 1972	40	England, Scotland and Wales, UK	31.6
Comstock et al. 1971	43	Maryland, USA	37.8
Cope et al. 1973	46	Sydney, Australia	30.1
Fabia 1973	73	Quebec, Canada	43.2
Kullander & Källén 1971	133	Malmö, Sweden	42.8
Meyer et al. 1974	169	Ontario, Canada	43.6
Niswander & Gordon 1972	189	14 US cities	47.6
Rantakallio 1969		Lapland and Oulu, Finland	23.4
Rush & Kass 1972	216	Boston, USA	46.9
Developing Areas			
Fortney 1979	79	Asia, developing ²	1.6
		Latin America ³	20.1
		Middle East and Africa ⁴	0.2
Kizer 1978	128	Caracas, Venezuela ⁵	27.4
Krishna 1978	131	Delhi, India ⁶	0.3/15.8 ⁷
Mukherjee & Mukherjee 1971	175	Simla, India ⁸	1.7/67.8 ⁹

^aExcept as noted, study populations are described in Tables 2 and 3.

²Includes Bangladesh, India, Indonesia, Pakistan, the Philippines, and Sri Lanka; number of women studied: 14,925.

³Includes Brazil, Chile, Colombia, El Salvador, Honduras, Mexico, Panama, Uruguay, and Venezuela; number of women studied: 68,035.

⁴Includes Egypt, Iran, Nigeria, Sudan, and United Arab Emirates; number of women studied: 78,803.

⁵Population: 2,095 women receiving prenatal care or giving birth at a Caracas hospital, March 1966-January 1967.

⁶Population: 1,393 women delivered of single infants without gross abnormalities, Pune Hospital, June 1971-May 1972.

⁷Smoking/chewing tobacco.

⁸Population: 2,886 consecutive women giving birth in a Simla hospital, January 1963-June 1969.

⁹Women of high social status/wives of semiskilled and unskilled laborers.

purities, and are often rolled into filter-tipped cigarettes. Western cigarettes are also more expensive, thus perhaps reducing per capita consumption.

Smoking Commercial Cigarettes

On the other hand, there are special health hazards in shifting to commercial cigarettes: traditional forms may be less dangerous because the smoke is not usually inhaled (116, 277). In the case of the water pipe, or *hookah*, in common use in Asia, water may remove nicotine and tar (277). Switching to commercial cigarettes encourages inhaling, since their tobacco is milder than those traditionally grown in most of the world (179), and once people learn to inhale they may tend to do so even when smoking stronger tobacco (134).

Also, there is some evidence that the commercial cigarettes sold in some developing countries are stronger than those sold under the same brand names in the industrialized nations. Muller reports that the tar content of four brands of cigarettes produced in the Philippines was 1.6 to 2.2 times higher than the

average for cigarettes bearing the same brand names that were tested in the US, the UK, and Australia (179).

In smoking, as is the case in other matters affecting health, the poor often find themselves at the greatest disadvantage. Less affluent smokers usually inhale more of each cigarette as an economy measure. For instance, Rhodesian researchers believe that Africans' habits of inhaling more and smoking each cigarette to the end contribute to the incidence of lung cancer even though they smoke relatively few cigarettes (89). By smoking unfiltered cigarettes and resorting more often to hand-rolled, lower grade tobaccos, low income smokers may increase their exposure to tar and nicotine. In India, filter-tipped cigarettes account for less than one-fourth of total production (232, 246). In fact, the most common Indian cigarette is *bidi*, which uses the leaf of the *temburni* tree as wrapper. About 250 billion were produced in 1977 (246). *Bidi* smoke contains a higher concentration of carcinogenic hydrocarbons and toxic agents than even the smoke of US nonfilter cigarettes (113).

While the patterns and forms of smoking in developing countries are varied and specific data are scarce, the broad trends are obvious: more people are smoking, and they are smoking in more hazardous ways. The question is not whether these trends will show up in national death rates, but how soon.

POLICY IMPLICATIONS

The health implications of smoking have been widely publicized in the developed world. By 1979 about two dozen developed countries, including Australia, New Zealand, Japan, the United States, the Soviet Union, and many European nations, had begun to introduce restrictions on smoking. But the financial and agricultural policy implications of heavy tobacco use have received far less attention. The United States, for instance, subsidizes tobacco growing at home and sales overseas while at the same time supporting anti-smoking campaigns at home. Many developing countries, spurred on by promotion from the multinational tobacco companies, are increasing tobacco production both as a valuable export crop for foreign exchange and to meet growing domestic demand. Health professionals throughout the world have a special responsibility to inform themselves and those they work with of the need both for individual decisions and government policies that take account of the hazards of tobacco use.

Benefits and Costs of Tobacco Use

Any assessment of tobacco policy must take account of the claimed economic benefits of tobacco use as well as the health-related costs. As Table 11 shows, tobacco is an increasingly important crop in many developed and developing countries. Tobacco is easy to grow and provides a ready source of cash to the small family farmers who still constitute most of the world's producers. Manufacture and wholesale distribution are largely in the hands of multinational corporations or of government monopolies that cooperate with the commercial firms and provide in most cases for orderly — and profitable — promotion and marketing. As an export product, tobacco makes an important contribution to foreign exchange. As a domestic consumer product, tobacco is one of the most heavily taxed of all commodities.

Table 14. Estimated Economic Returns Attributable to US Tobacco and Tobacco Products, 1976 and 1977 (in \$ Millions)

	Receipts	Value Added	Income	Wages	Other Costs
Farmers*	2,225	1,300	700	600	970
Marketers	2,300	75	30	20	25
Processors	2,700	228	90	67	71
Exports*†	1,731	50	16	17	17
Manufacturers	4,200	1,500	600	600	300
Distributors**	12,900	7,400		2,000	
Taxes*	6,200				
Consumer Expenditure* = Income Generated* + Taxes*					
	\$17,000	=	\$10,800	+	\$6,200

*1977 figures; others are 1976 figures.

†Imports in 1977: \$373

**Excluding taxes

Source: Miller (US Department of Agriculture) (173)

The tax revenues provided by tobacco play an important role in public policy. Less resented than income or property levies, they are far easier to collect. Moreover, they provide considerable sums of money. In Britain, for example, about 70 percent of the price of a package of cigarettes goes to the government (65). In China a 60 percent tax is levied on cigarettes (154). In the Philippines tobacco revenues are said to provide nearly half of government revenues (4). In Tanzania payments from the government tobacco monopoly cover the entire national health budget (179). And in a number of other countries taxes or other payments to government help to insure high level influence (179). Finally, millions of retailers pocket high profit margins for the sale of cigarettes, sometimes sold two or three at a time. Also, they welcome a product that draws consumers in for other purchases.

Yet, in the United States at least, where tobacco was first developed as a colonial product for export, the health costs of domestically consumed tobacco now far outweigh the dollar returns to producers, manufacturers, exporters, and tax collectors (see Tables 14 and 15). While total consumer spending (plus exports) now amounts to about \$19 billion and supports jobs for 1.3 million people (173), the cost to US citizens in lost production from sickness, health care, and loss of life and property destroyed by fire totals \$27.5 billion (147). This is about 50 percent higher than the income generated and more than four times higher than the taxes collected, even though the taxes alone are approximately triple the receipts to the original farm producer. Incidentally, US domestic tobacco sales are 1½ times the amount spent on all drugs and sundries (173).

In the developing countries, the health costs to society may seem to be lower, but the cost to individuals of a package of cigarettes represents a far greater sacrifice of per capita income. It may be equivalent to the price of meat for a family meal or fresh fruit or vegetables for a pregnant woman. (In fact, smoking often serves as an appetite depressant where food is not available.) Under present conditions of low income, poor nutrition, and limited health care prevailing in many developing countries, tobacco adds an extra burden of health risk.

The land used to raise tobacco is not available to raise food, and this too may contribute to malnutrition and higher mortality. Some 4.4 million hectares, 71 percent of it in developing countries, were devoted to tobacco growing in 1977 (243). Furthermore, tobacco is cured with wood smoke: a tree is burned for every 300 cigarettes produced in the Third World, and an acre of woodland, for every acre of flue-cured Virginia tobacco grown (179). Thus tobacco production aggravates the already critical shortage of firewood in much of the developing world (66).

Cigarette production is a capital intensive industry, the second most intensive in the world, according to F. Clairmonte of the UN Conference on Trade and Development. The US cigarette industry, for example, invests over \$108,000 in machinery for each worker it employs (179). Even in developing countries, where technology may be less sophisticated, cigarette manufacturing produces relatively few jobs and consumes scarce capital. Some of this expenditure of financial and natural resources might be recouped by the inflow of foreign exchange. This inflow may be more apparent than real, however. M. Muller, writing for the British organization War on Want, points out that the importation of filters, paper, and packaging for cigarettes can, as it has in the case of Zambia, cancel out the exchange benefits of exporting some of the product (179).

Although many developing countries now grow tobacco, many also import both Western tobacco for blending and Western cigarettes. These purchases use valuable foreign exchange that might otherwise be spent for development. Developing areas that imported more than 1,000 metric tons of tobacco or tobacco products in 1977 were Algeria, Ecuador, Egypt, Ghana, Hong Kong, Ivory Coast, Jamaica, Malaysia, Morocco, Senegal, Singapore, Tunisia, Uruguay, and Zaire (247).

Overall, despite the payments to small farmers and distributors and the substantial revenues to commercial firms and governments, tobacco becomes a net cost rather than a benefit to society whenever a large proportion of the population smokes enough to suffer the impact of tobacco-induced disease. Yet

Table 15. Estimated Economic Costs of Tobacco Use in the United States, 1976

	Estimated %age of cases involving tobacco use	Costs (in millions of \$US)			
		Health Care Direct Costs	Indirect Costs (Lost Earnings)		Property Costs
			Morbidity	Mortality	
Neoplasia	20.0	1,077.4	230.1	3,372.7	—
Circulatory System Disease	25.0	3,797.9	2,141.5	7,582.4	—
Respiratory System Disease	40.0	3,300.6	3,785.2	1,833.6	—
Fires	1.1	48.1	35.0	159.3	175.9
Total		8,224.0	6,191.8	12,948.0	175.9
					27,539.7

Source: Adapted from Luce and Schweitzer (147)

the financial pressures facing governments have impeded the development of health-oriented tobacco policies. In the long run, however, as the World Health Organization (WHO) Technical Report *Smoking and Its Effects on Health* pointed out in 1974, "economic cost-benefit studies are not conclusive, since the true gain from reducing smoking will be in human terms and in the reduction of ill-health and of premature death, rather than merely in monetary terms" (277).

Policies to Control Tobacco Use

As medical knowledge and public awareness of the hazards of smoking advanced, the English-speaking and Scandinavian countries, where levels of smoking were high, became the first to consider government policies to discourage tobacco use. But policy change has been slow. As early as 1957 the British Medical Research Council released a comprehensive review of research findings and concluded that cigarette smoking was the major cause of increasing mortality from lung cancer (160). In 1962 the Royal College of Physicians of London published a similar report (213).

In the United States the 1964 Report of the Surgeon General's Advisory Committee marked a watershed in public policy (258). Upon the unanimous finding of a panel of distinguished

"Cigarettes are not a prime necessity. We have a severe shortage of food. We have to pay large sums for the import of food. Why then should we divert an increasing quantity of land, fertilizer and water for tobacco cultivation? . . . What are our priorities? Do we want an emphasis on a commodity which ultimately ends up in smoke? Why should we pay British-American Tobacco for increasing the susceptibility of our people to disease, especially cancer?"

**Father Tissa Balasuriya
Center for Society and Religion
Sri Lanka (179)**

experts that "cigarette smoking is a health hazard of sufficient importance in the United States to warrant remedial action," the US Public Health Service gradually took on leadership in combating smoking. Similarly in both Norway and Finland official concern over the dangers of smoking was first expressed in the mid-1960s, yet major policy initiatives and legislation were delayed until the mid-1970s.

In 1974 the World Health Organization convened an Expert Committee on Smoking and Its Effects on Health and issued a report (277). The Expert Committee made extensive recommendations with respect to actions that national governments and international agencies could take. A new report will be issued in 1979 (see box, col. 1). The objectives for government programs recommended in the 1974 WHO report are:

1. As few young people as possible should start smoking and those doing so should start as late as possible.
2. As many smokers as possible should be encouraged and assisted to stop smoking.
3. Those who are unable to stop smoking should try to reduce their exposure to such harmful substances in smoke as tar, nicotine, and carbon monoxide (276).

There are a number of possible components in a comprehensive, health-oriented tobacco-control policy, but no country has yet adopted the full range of actions that have been proposed. These include:

- expanding research
- undertaking public education campaigns
- raising taxes, especially on high tar and nicotine products
- establishing government standards for production
- reducing export subsidies
- eliminating agricultural extension and government support services
- requiring health warnings on packages of tobacco products and in advertisements
- labelling packages to indicate levels of harmful components
- limiting or prohibiting advertising
- limiting sales, e.g., to minors or in certain locations
- prohibiting smoking in public areas or work places
- establishing differential life insurance rates for smokers

Most of the developed countries have adopted some restrictions along these lines. Most of the developing countries have not, with the exception of some of the major importing countries, which, not surprisingly, have been among the first to recognize the costs of tobacco use (see Table 16).

Given the economic influence of the industry, governments have found it easiest to expand research. In fact, tobacco companies have often contributed to research projects and are

WHO PANEL CONVENED; REPORT DUE BY JUNE 1979

Continuing its concern over the effects of smoking as an international health problem, the World Health Organization (WHO) convened an Expert Committee on Smoking Control October 23-28, 1978. The Expert Committee's report will be released in mid-1979, it is anticipated, in time for the Fourth World Conference on Smoking and Health, to be held in Stockholm in June 1979, under the auspices of the Swedish government.

Members of the WHO Expert Committee on Smoking Control are:

Professor O.O. Akinkugbe, Vice Chancellor, Ahmadu Bello University, Zaria, Nigeria

Dr. K. Bjartveit, Director, National Council on Smoking and Health, Oslo, Norway (Rapporteur)

Dr. H. Coudreau, Director-General, Comité National contre la Tuberculose et les Maladies Respiratoires, Paris, France

Dr. E. Crofton, Medical Director, Scottish Committee, Action on Smoking and Health, Edinburgh, Scotland
Sir George Godber, Cambridge, England (Chairman)

Dr. N. Gray, Director, Anti-Cancer Council of Victoria, East Melbourne, Australia (Rapporteur)

Dr. D. Horn, c/o Office on Smoking and Health, Rockville, Maryland, USA

Dr. D. Loransky, Director, Central Institute for Scientific Research in Health Education, Ministry of Health of the USSR, Moscow, USSR

Dr. L. Ramström, Director-General, National Smoking and Health Association, Stockholm, Sweden

Dr. J. Sulianti Saroso, Adviser to the Minister of Health, Jakarta, Indonesia

Secretariat:

Dr. R. Masironi, Scientist, Cardiovascular Diseases, WHO, Geneva, Switzerland (Secretary)

S. Fiuss, Health Legislation, WHO, Geneva, Switzerland

themselves financing extensive research to find safer tobacco products. The introduction of a synthetic tobacco cigarette in the UK was not successful, however, and has discouraged research into tobacco substitutes (246). Research continues to develop tobacco products with less tar and nicotine content even as public health officials debate the ethics of helping to develop a product that is at best only slightly less harmful.

Raising taxes or prices has proved to be another relatively uncontroversial way to discourage smoking. In recent years taxes have been increased in developed and developing countries ranging from Switzerland to Venezuela. In Venezuela, part of the tax is being used by the National Tobacco Fund for development in the rural tobacco regions (154). In Britain a graduated tax was imposed in 1978, with the highest rates on high tar cigarettes (244). The impact of price increases on sales is limited, since the demand for tobacco products is relatively inelastic. Nevertheless, in Belgium, Luxembourg, the Netherlands, West Germany, India, and Italy recent price boosts have reduced sales somewhat (246). In the Philippines declines in purchasing power have served to cut consumption (246). Although one analysis of per capita levels of cigarette consumption in 47 countries found that total per capita spending, not prices, was the strongest determinant of cigarette consumption, higher prices for cigarettes do exert some negative pressure on consumption (194).

With respect to tobacco advertising, a 1974 survey of tobacco regulatory policies found that, whereas 20 of 25 developed countries imposed some restrictions on tobacco promotion, only 13 of 49 developing countries did (5). Most of the larger developed countries have banned radio and television advertising of cigarettes and usually of other tobacco products as well. Press advertising is also banned in Iceland, Italy, Poland, Sweden, the Soviet Union, Norway, and Finland, among others (225).

A much smaller number of developing countries have instituted such laws. Peru, for example, prohibits radio and television advertising before 9 p.m. A near-complete media ban on advertising was instituted by Singapore in 1970, prohibiting all forms of promotion of tobacco, written or oral, and exempting only foreign periodicals (277). Burma, Iraq, Korea, Saudi Arabia, Turkey, and Zambia all impose some limits on tobacco advertising, mainly on radio and television (5). Since 1974, Colombia, Egypt, India, and Mexico also have imposed some restrictions on tobacco advertising (225).

Health warnings on cigarette or other tobacco product packages are becoming more common. In the United States, for example, cigarette packages carry the statement: "Warning: The Surgeon General Has Determined That Cigarette Smoking Is Dangerous to Your Health." Recently the Secretary of Health, Education, and Welfare has embarked on a more vig-

Table 16. National Policies to Control Promotion and Use of Tobacco, 1978

Developed	Restrictions on Advertising	Health Warning On Packages	Restrictions On Sales To Minors	Restrictions On Smoking	Anti-Smoking Education	Developing	Restrictions On Advertising	Health Warning On Packages	Restrictions On Sales To Minors	Restrictions On Smoking	Anti-Smoking Education
Australia	✓	✓				Burma	✓				
Austria	✓					Colombia	✓	✓			
Belgium	✓	✓		✓		Costa Rica		✓			
Bulgaria	✓		✓		✓	Ecuador		✓			
Canada	✓	✓				Egypt	✓				
Czechoslovakia	✓					Greece					✓
Denmark	✓					India	^a	✓			
Finland	✓	✓	✓	✓	✓	Iraq	✓				
France	✓	✓			✓	Korea, South	✓				
Germany, F.R.	✓	✓			✓	Malaysia		✓			
Iceland	✓	✓				Mexico	✓	✓			
Ireland	✓	✓				Morocco				✓	
Italy	✓		✓	✓	✓	Mozambique	✓				
Japan	✓	✓				Panama	^b	✓			
Malta	✓					Peru	^b	✓			
Netherlands	✓					Romania				✓	
New Zealand	^a	^a	✓			Saudi Arabia	✓				
Norway	✓	✓	✓			Singapore	✓			✓	
Poland	✓		✓	✓	✓	Spain	✓				
Soviet Union	✓		✓		✓	Thailand			✓		
Sweden	✓	✓				Turkey	✓				
Switzerland	✓	✓	✓			Venezuela		✓			
United Kingdom	✓	✓	✓			Zambia	✓				
United States by state	✓	✓	45	30 ^c	34 ^d						
Total	23	13	10	7	6	Total	12	9	1	3	1

^aRestrictions on a voluntary basis.

^bWarnings required in advertising.

^cOf these, 22 are considered relatively stringent or extensive.

^dMandatory drug, alcohol, and tobacco education programs.

Source: US Office on Smoking and Health (22¹), World Tobacco (5).

orous anti-smoking campaign despite continuing opposition from tobacco growers and producers.

To go beyond that warning, the Massachusetts Department of Public Health has recently recommended to the federal government that the warning label on cigarette packages be revised to read: "Cigarette smoking is hazardous to your health and can cause fatal cancer, heart disease and lung disease. Smoking during pregnancy increases the risk of complications, and the risk of death of the unborn baby or newborn infant" (76).

Package warnings are also required in Australia, Belgium, Canada, Finland, France, Iceland, Ireland, Japan, Norway, Sweden, Switzerland, New Zealand, and the United Kingdom. Among the developing countries, nine — Colombia, Costa Rica, Ecuador, India, Malaysia, Mexico, Panama, Peru, and Venezuela — now also require warnings (225).

Although the People's Republic of China has captured world attention with massive public health campaigns against venereal disease, malaria, and schistosomiasis, only recently have voices there been raised against smoking. Both Mao Tse-tung and Chou En-lai were chain smokers. Their example, plus the taxes collected on each package of cigarettes, may have delayed government action against smoking. But there are signs that this is changing. In late 1978 the *Kwangming Daily*, a Peking newspaper for intellectuals and professionals, carried an article by two doctors warning of the links between ciga-

rettes and various cancers, respiratory disease, and circulatory system diseases (154). This contrasts with earlier reports that cigarette smoking was "not considered a major factor in the causation of bronchogenic cancer" even though smoking has increased rapidly in the past 30 years and lung cancer incidence in Shanghai, for example, has doubled in the last decade (124). Concern over the growing number of young people who smoke as well as the need to put more land into food production may lead to more health-oriented tobacco policies (154).

Educational Campaigns

Anti-smoking campaigns in a number of developed countries seem to be playing a more important role both in encouraging smokers to quit and in discouraging others from taking up the habit. In the US, Japan, France, and the United Kingdom, for example, these efforts have halted any increase in consumption and are contributing to slight declines (246). Although there has not been a single, coordinated effort in the United States, various public and private organizations have been actively encouraging people to quit or reduce smoking for nearly two decades. Examining actual and predicted per capita cigarette consumption, K.E. Warner found an immediate but short-lived decrease of 4 to 5 percent in annual per capita consumption following the Surgeon General's report in 1964. By 1975, he found, a cumulative decline of 22 percent in smoking as a result of ongoing anti-smoking publicity and public policies had taken place (267).

Educational efforts may also have had tangible effects in France. The French Ministry of Health reported in 1977 that a year-long educational campaign had produced a 15 percent decline in the number of cigarettes consumed by adults and an even greater decline among the young. The number of smokers was reduced by 3 percent (2).

The United States experience suggests an indirect relationship between public education and public policy: Warner concludes that the tax increases, which helped to discourage usage, would not have been politically possible without extensive anti-smoking publicity (267). Conversely, in Finland, public debate over proposed legislation had a strong educational effect, making the public aware of the health impact of smoking (137). Where polls have been taken, 80 to 90 percent of the public approve bans on tobacco promotion (29, 137).

Regulations to restrict sales to minors (and even to limit vending machine sales, as in Finland) have also been well accepted. Indeed, some of these regulations date back to the last century (29). Even today few tobacco companies argue for the right to stimulate sales among minors even though advertising and promotion is often clearly aimed in that direction.

Beyond indirect measures affecting taxation, advertising, public education, and restrictions on sales to minors, pressure is mounting to adopt more stringent policies banning smoking in public areas and places of employment. The comprehensive 1975 Finnish legislation, for example, includes such a ban (137). In the United States, some 30 states and cities such as New York and Washington, D.C., limit smoking in elevators, public transit, food stores, restaurants, or other enclosed public areas. Six states ban smoking in schools (225). In California, however, a referendum to place even more stringent limits on smoking indoors was defeated in 1978, following an extensive public relations campaign by tobacco interests that played on popular dislike of government regulation. A number of private or public health organizations, such as the German Medical Society and Brazil's Federal Council of Medicine, prohibit



Infants exposed to tobacco smoke have more respiratory tract ailments. (Health Education Council, UK)



The US Department of Health, Education, and Welfare has embarked on a national campaign to discourage young children from taking up smoking. (Office of Smoking and Health, USDHEW)

smoking during their meetings, and smoking is not permitted in official meetings of WHO (277). With new attention to the possible adverse affects of "passive smoking" and with the number of ex-smokers growing, the developed countries will probably see more of such restrictions.

So far the most controversial policy area, still untouched in the United States and ignored elsewhere, involves tobacco production, agricultural support services, and exports. Governments continue to supervise or regulate production for sales and price support rather than safety; they continue to provide agricultural extension services to boost productivity; and, like the United States, they welcome and even subsidize export sales while acting to reduce domestic consumption (179).

There has been little substantial change since 1974 despite growing evidence that the long term health costs of tobacco use will outweigh the short term financial returns. As in the developed countries, it should be the responsibility of health professionals, above all, to recognize and publicize the dangers in developing nations.

Health and Family Planning Professionals

Physicians, including obstetricians and gynecologists, can be a valuable source of information on smoking (47). In the United

States over 90 percent of practicing physicians believe that they are responsible for setting a good example by not smoking. The drop in the percentage of US doctors who smoke, from 29.6 percent in 1967 to 21.0 percent in 1975, is testimony to that belief (249). In developing countries, however, medical schools often show a higher proportion of smokers than any other higher educational curriculum. For example, in Uganda a 1969 survey found that over 50 percent of third-year medical students smoked (14), and smoking rates among Malaysian medical students reported in 1975 showed a jump from 15.5 percent of the first-year class to an average of 28.8 percent for the third-year and beyond (195). Among male and female medical students in Lagos, Nigeria, smoking rates are 72 and 22 percent, respectively (68). Physicians in developing countries may need first to inform and educate themselves to the dangers of smoking before they can effectively advise their patients.

In its 1974 report WHO suggested that special attention should be given to:

- Health workers**, who should recognize the importance of their role in discouraging smoking and be prepared to assist people who encounter difficulty in stopping smoking. They should:
 - (i) themselves set an example by not smoking, especially in the presence of young people and patients, and encourage their patients and families to stop smoking;
 - (ii) discourage young people from starting to smoke;

- (iii) draw the attention of smokers with impaired lung function, those known to be at risk of ischaemic heart disease, and pregnant women, to the special dangers of smoking for them;
- (iv) urge that action against smoking should form part of all medical and health care programmes, and actively participate in health education activities, expressing support for policies and programmes for the control and prevention of smoking (277).

Family planning programs, in their role as promoters of reproductive health, are a particularly appropriate vehicle for education on the danger of tobacco to childbearing. Mothers' classes offer an excellent opportunity to change pregnant women's smoking habits and also to discover which educational approaches are the most effective (77). So far, however, there has been little study of smoking cessation programs for prospective mothers. An intensive US program involving 11 pregnant women achieved a reduction in average number of cigarettes smoked for 9 of the participants (48), but research in England suggests that those most likely to stop smoking are those who smoked less at the beginning of pregnancy (58). This should be expected; it indicates not so much a failure of anti-smoking programs as it does the strength of the tobacco habit, which is properly described as "drug dependence" (214).

Despite an increasing awareness among specialists of the dangers of maternal smoking to the fetus and neonate, this information has yet to reach many women in their childbearing years even in the developed countries. A government-sponsored survey conducted in the United States in 1975 found that only 60 percent of women questioned believed at the time of their last pregnancy that smoking was harmful to the fetus (254). The percentage of women who are aware of tobacco's effects on pregnancy is probably much lower in countries having no anti-smoking campaigns.

The Massachusetts Department of Public Health has recently outlined steps that those who provide obstetrical care should take to dissuade pregnant women from smoking. These recommendations could be adapted for use in developing countries (see box).

Massachusetts Department of Public Health Recommendations to Health Care Specialists Regarding Smoking Among Pregnant Women

1. In the initial prenatal visit, the health care specialist should include tobacco in the usual list of drugs that are known to adversely affect the outcome of pregnancy and are thus to be avoided. Mention may be made that during pregnancy, when use of all pharmacologic agents is to be kept to a minimum, cigarette smoke, which contains over 1,000 chemical agents, is of special concern.
2. Pregnant women should be told that evidence to date suggests that they are at especially high risk for detrimental effects of smoking on the pregnancy if they have had a history of previous perinatal loss, bleeding or placental complications, if they are anemic or if they are in the older age group.
3. Any woman with bleeding at any time during pregnancy should be questioned closely on whether or not she smokes, and the dangers of smoking to the fetus re-emphasized.
4. Health facilities should not permit smoking in any areas where staff and patients come in contact. Prominent "No Smoking" signs should be displayed in all patient areas and the prohibition enforced.

Source: Fielding & Russo (76)

In the last century health improvements in the developed countries were achieved largely by means of reforms in sanitation implemented before mechanisms of infection were fully understood. By the same token, anti-tobacco measures should not wait for the results of further research on tobacco and health, even though such efforts are worthwhile and needed (277). There is no doubt that tobacco impairs adult health and healthy childbearing. Further inquiries into the epidemiology and biological mechanisms of tobacco's effects will be valuable, but the need for measures to reduce the use of tobacco is crucial and immediate.

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